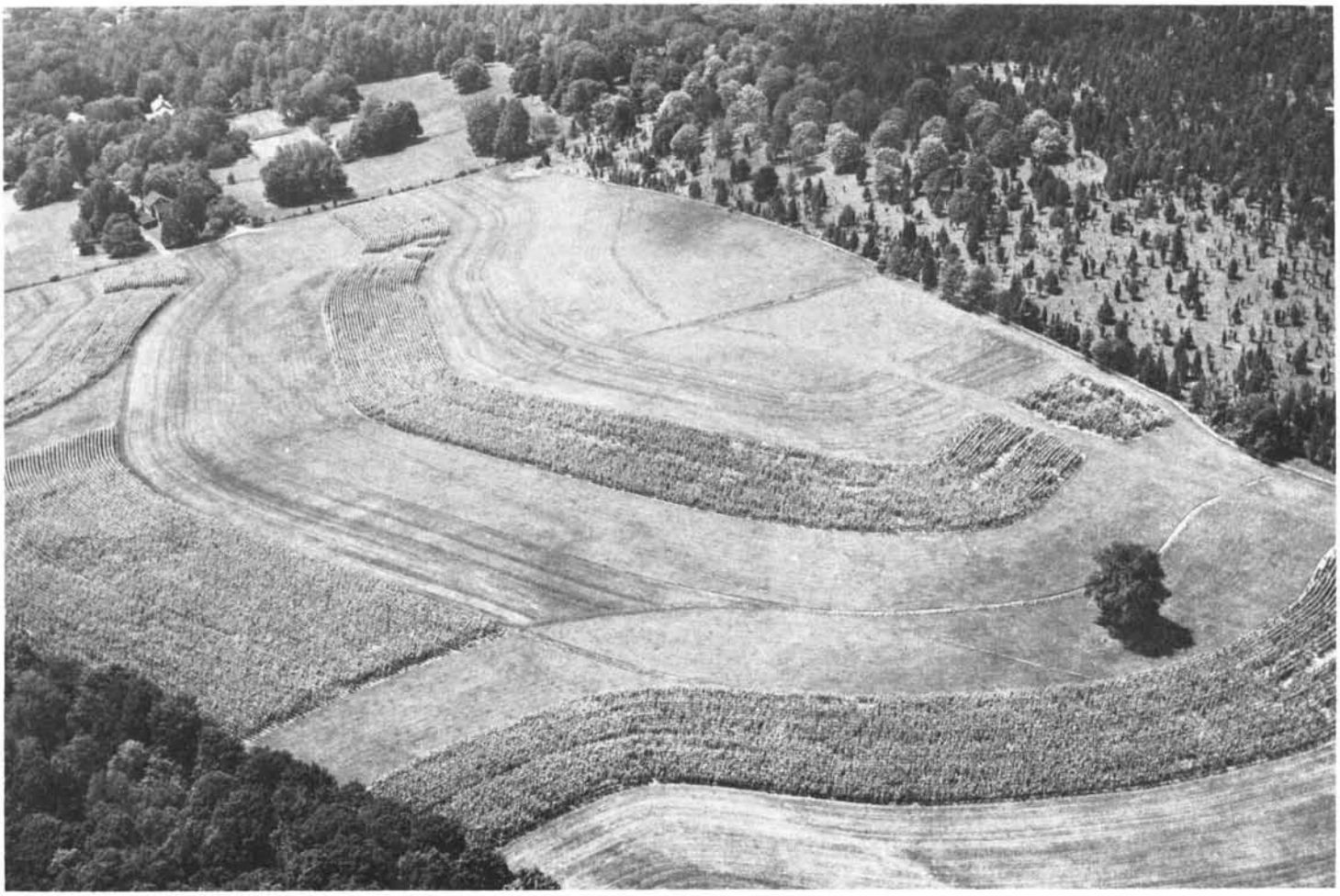
SOIL SURVEY OF

Morris County, New Jersey



United States Department of Agriculture
Soil Conservation Service

In cooperation with
New Jersey Agricultural Experiment Station
Cook College, Rutgers University

and the
New Jersey Department of Agriculture
State Soil Conservation Committee

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1964–68. Soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1968. This survey was made cooperatively by the Soil Conservation Service, the New Jersey Agricultural Experiment Station, Cook College, Rutgers University, the New Jersey Department of Agriculture, State Soil Conservation Committee, and the Board of Chosen Freeholders of Morris County. It is part of the technical assistance furnished to the Morris County Soil Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, residences, and recreation.

Locating Soils

All the soils of Morris County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and shows the capability classification of each. It also shows the page where each soil is described.

Individual colored maps that show the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those that have a moderate limitation can be colored yellow, and those that have a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussion of capability classification.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Wildlife."

Foresters and others can refer to the section "Woodland," where the soils of the county are grouped according to their suitability for trees.

Community planners and others can read about soil properties that affect the choice of sites for dwellings, industrial buildings, and recreation areas in the section "Town and Country Planning."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation, Morphology, and Classification of the Soils."

Newcomers in Morris County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given at the beginning and end of the publication.

Cover: Stripcropping to control erosion on Edneyville soils in Mendham Township, Morris County.

Contents

Issued August 1976

SOIL SURVEY OF MORRIS COUNTY, NEW JERSEY

BY CARL F. EBY, SOIL CONSERVATION SERVICE

SOILS SURVEYED BY CARL F. EBY, LESTER L. SEGLIN, AND ROY A SHOOK, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE NEW JERSEY AGRICULTURAL EXPERIMENT STATION, COOK COLLEGE, RUTGERS UNIVERSITY, AND THE NEW JERSEY DEPARTMENT OF AGRICULTURE, STATE SOIL CONSERVATION COMMITTEE

MORRIS COUNTY is in the central part of northern New Jersey (fig. 1). It is in the New York-Northeastern New Jersey Standard Consolidated Area. Morristown, the county seat, is near the center of the county. The county is about 30 miles from north to south and 30 miles from east to west. Its land area is 299,520 acres, or approximately 468 square miles. In addition, it has about 10.7 square miles of lakes and reservoirs. The population of Morris County in 1970 was 383,454.

The county is rapidly becoming urbanized, but large wooded tracts are in the rough, mountainous area in the northern part of the county. Even in this area developments are beginning, but because of the severe limitations imposed by the soil characteristics, the developments consist of high-priced homes through which the developer is able to absorb the additional costs of overcoming the soil limitations. In the southeastern part of Morris County, large tracts are being developed for garden apartments and industrial parks. Other areas have been set aside for nature reservations and for open-space activities. The western part of the county, mainly Washington Township, has the only extensive farm areas.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Morris County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes; the size and speed of streams; the kinds of native plants or crops; the kinds of rock; and many facts about the soils (*10*).[1] They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface

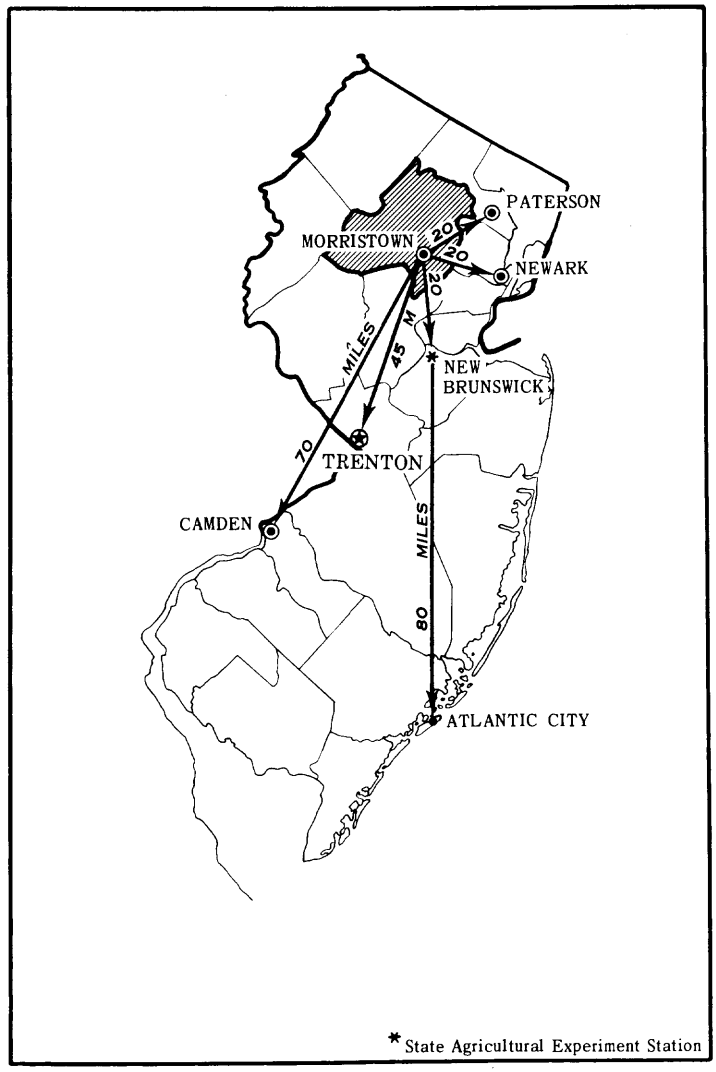


Figure 1.—Location of Morris County in New Jersey.

[1] Italic numbers in parentheses refer to Literature Cited, p. 108.

down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Rockaway and Parsippany, for example, are the names of two soil series. All the soils in the United States that have the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Rockaway very stony sandy loam, 3 to 15 percent slopes, is one of several phases in the Rockaway series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Morris County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Penn-Klinesville shaly silt loams, 15 to 25 percent slopes, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils or of two or more. If two or more dominant series are represented in the group, the name of the group ordinarily consists of the names of the dominant soils, joined by "and." Boonton and Haledon extremely stony soils, 8 to 15 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the detailed soil map and are described in the survey, but they are called land types and are given descriptive names. Rock outcrop is an example.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kind of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or a high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil, and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Morris County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map that shows soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who

want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in this survey have been grouped into three general kinds of landscape. Each of the broad groups and their included soil associations are described in the following pages. The terms for texture used in the title of the associations apply to the texture of the surface layer. For example, in the title of association 1 the words "gravelly sandy loam" refer to the texture of the surface layer.

Soils Formed in Young Glacial Till

The associations in this group are in the northern half of the county. The soils are dominantly gravelly and extremely stony sandy loams underlain by glacial till that ranges from gravelly loamy sand to silt loam. Outcrops of bedrock are common in some steep areas. The soils are on ridges and in valleys.

1. Rockaway-Hibernia-Urban land association

Deep, well drained to somewhat poorly drained, gently sloping to steep gravelly sandy loams and stony to extremely stony loams and sandy loams that overlie granitic gneiss; on uplands

The soils in this association formed in stony to extremely stony sandy loam glacial till. The till is of mixed origin but is derived largely from fragments of granitic gneiss. Bedrock is at a depth of 4 to 10 feet or more and varies greatly within short horizontal distances. A few rock outcrops are present.

This association covers 25 percent of the county. It is 50 percent Rockaway soils, 10 percent Hibernia soils, 10 percent Urban land-Rockaway complexes, and 30 percent minor soils.

Rockaway soils are on uplands; they are gently sloping to steep and well drained to moderately well drained. They have a fragipan in the lower part of the profile. Hibernia soils are in depressions and drainageways and at the base of steep slopes. These soils are gently sloping to steep and somewhat poorly drained. They have a fragipan in the lower part of the profile. The areas of Urban land have been cut, filled, smoothed, or otherwise mixed during construction. Most areas are covered by buildings or pavement. Most of the soils in the remaining open spaces have been reworked to the extent that the original soil profile cannot be recognized.

Minor soils are in the Ridgebury, Riverhead, and Pompton series. Ridgebury soils are in drainageways and depressions. Riverhead and Pompton soils are on terraces and outwash plains.

The soils in this association are limited for farming and community development by steep slopes, stoniness, and slow permeability in the fragipan. Hibernia and Ridgebury soils are also limited by wetness. They have a fragipan that causes lateral seepage of water into excavations and foundations and restricts the growth of roots and the downward movement of water.

This association is poorly suited to farming and most community development. It is well suited to open space and recreation.

Most areas of this association are woodland. A few areas have been cleared and are cultivated or used for pasture. Extensive areas are in residential and recreational developments. Urban land is used for building sites and other nonfarm uses.

2. Rockaway-Rock outcrop association

Deep, well drained and moderately well drained, strongly sloping to very steep very stony and extremely stony sandy loams that overlie granitic gneiss, and strongly sloping to very steep rock outcrops; on uplands

The soils in this association formed in stony to extremely stony sandy loam glacial till. The till is of mixed origin but is largely derived from fragments of granitic gneiss. Bedrock is at the surface in places but ranges to a depth of more than 10 feet, and depth varies greatly within short horizontal distances.

This association covers 10 percent of the county. It is 50 percent Rockaway soils, 40 percent Rock outcrop, and 10 percent minor soils.

Rockaway soils are on uplands; they are strongly sloping to very steep and well drained to moderately well drained. They have a fragipan in the lower part of the profile. Rock outcrop is mainly granitic gneiss; on Green Pond Mountain, however, it is mainly red quartzite and conglomerate.

Minor soils are in the Hibernia, Ridgebury, and Riverhead series. Hibernia and Ridgebury soils are in depressions and drainageways. Riverhead soils are on terraces and outwash plains.

The soils in this association are limited for farming and community development by rock outcrop over almost half of the area, strongly sloping to steep slopes, stoniness, slow permeability, and the fragipan, which restricts the growth of roots (fig. 2). Small areas of Hibernia and Ridgebury soils are also limited by inadequate drainage.

This association is poorly suited to farming, community development, and most recreational uses. It is suited to wildlife habitat and open space.

Almost all areas of this association are woodland.

3. Netcong-Rockaway association

Deep, well drained and moderately well drained, gently sloping to very steep gravelly, very stony, and extremely stony sandy loams that overlie granitic gneiss; on uplands

The soils in this association formed in gravelly, stony, or extremely stony sandy loam glacial till. The till is of mixed origin but is derived largely from fragments of granitic gneiss. Bedrock is generally below a depth of 10 feet.

Figure 2.—**Housing development on gently sloping to strongly sloping soils in Rockaway-Rock outcrop association. Steeper soils are wooded.**

This association covers 5 percent of the county. It is 40 percent Netcong soils, 40 percent Rockaway soils, and 20 percent minor soils.

Netcong soils are on rolling uplands. They are gently sloping to strongly sloping and well drained. Rockaway soils are on uplands; they are gently sloping to very steep and well drained to moderately well drained. They have a fragipan in the lower part of the profile.

Minor soils are in the Hibernia, Ridgebury, Parker, Califon, and Riverhead series. Hibernia, Ridgebury, and Califon soils are in drainageways and depressions. Parker soils are on the top and sides of ridges. Riverhead soils are on terraces and outwash plains.

The soils in this association are limited by very steep slopes, many stony to extremely stony areas, and seasonal seepage on top of the more slowly permeable subsoil.

Except for the steep, stony, or wet soils, this association is suited to farming, community development, open space, and wildlife habitat (fig. 3). The steep, stony, or wet soils are better suited to open space, wildlife habitat, or low-intensity recreation than to other uses.

About half of this association was once cleared and farmed. Some areas are reverting to woodland. Many areas are used for residential, commercial, and industrial development.

4. *Holyoke-Haledon-Boonton association*

Shallow and deep, well drained to somewhat poorly drained, gently sloping to very steep rocky silt loams, silt loams, gravelly loams, and extremely stony loams that overlie basalt or shale; on uplands

The soils in this association formed in thin to thick deposits of glacial till. The till is derived mostly from basalt and red to brown shale and sandstone, but it contains some fragments of granitic gneiss. Rock outcrops are hard but are fractured into large blocks.

This association covers 1 percent of the county. It is 40 percent Holyoke soils, which include areas of Rock outcrop; 30 percent Haledon soils; 10 percent Boonton soils; and 20 percent minor soils.

Holyoke soils are on side slopes of basalt ridges. They are gently sloping to steep, well drained, and shallow. Haledon soils are on undulating and rolling, low hills. They are gently sloping to strongly sloping, somewhat

Figure 3.—**Urbanization in an area of Netcong-Rockaway association, mostly on the less sloping soils. Steeper soils remain wooded. Controlling erosion and runoff is a concern on these soils.**

poorly drained, and deep. They have a fragipan in the lower part of the subsoil. Boonton soils are on ridgetops, side slopes, and hills. They are gently sloping to strongly sloping and well drained to moderately well drained. They have a fragipan in the lower part of the subsoil.

Minor soils are in the Riverhead, Pompton, Neshaminy, and Hibernia series and the Ellington series, loamy subsoil variant. Riverhead and Pompton soils are on terraces and outwash plains. Neshaminy soils and the Ellington loamy subsoil variant are on the top and sides of ridges. Hibernia soils are in depressions and drainageways and at the base of steep slopes.

The soils in this association are limited by strongly sloping to steep areas, shallow depth to bedrock, extensive areas of Rock outcrop or stony soils, the hazard of erosion, and seepage from the top of the bedrock or the fragipan into cuts, foundations, and excavations. Hibernia soils are also limited by wetness.

This association is poorly suited to farming and most community development. It is suited to low-density development and open space.

Most areas of this association are woodland. Some small areas have been cleared and are used for pasture. Some areas, particularly those that afford an attractive view, are used as homesites, although the cost of site preparation is high.

5. Haledon-Urban land-Boonton association

Deep, well drained to somewhat poorly drained, gently sloping and strongly sloping silt loams, gravelly loams, and extremely stony loams that overlie basalt or shale; on uplands

The soils in this association formed in thick deposits of glacial till. The till is derived mostly from basalt and red to brown shale and sandstone, but it includes some fragments of granitic gneiss. Basalt or shale bedrock is generally below a depth of 10 feet. A few small outcrops of basalt are present in strongly sloping areas.

This association covers 5 percent of the county. It is 40 percent Haledon soils, 20 percent Urban land, 15 percent Boonton soils, and 25 percent minor soils.

Haledon soils are on undulating and rolling low hills. These soils are gently sloping to strongly sloping and somewhat poorly drained. They have a fragipan in the lower part of the subsoil. The areas of Urban land have been cut, filled, smoothed, or otherwise mixed during construction. Most of the areas are covered by buildings or pavement. Most of the soils in the remaining open spaces have been reworked to the extent that the original soil profile cannot be recognized. Boonton soils are on ridgetops, side slopes, and hills. These soils are gently sloping to strongly sloping and well drained

and moderately well drained. They have a fragipan in the lower part of the subsoil.

Minor soils are in the Holyoke, Riverhead, Pompton, Whippany, Parsippany, and Haledon series. Holyoke soils are on the sides of basalt ridges. Riverhead and Pompton soils are on terraces and outwash plains. Parsippany and Whippany soils are in the basin formerly occupied by Glacial Lake Passaic. Haledon soils are on undulating and rolling low hills in a complex with Urban land.

The soils in this association are dominantly somewhat poorly drained. Slow permeability in the fragipan retards percolation and causes lateral movement of water in wet seasons. The water seeps into cuts, excavations, and foundations, which results in slumping, erosion, and difficulty in providing drainage.

If drainage and erosion are controlled, this association is suited to most farming and community developments. It is poorly suited to onsite disposal of sewage because of the somewhat poor drainage and slow permeability.

About half of this association was once cleared and farmed. Most of it has been idle for many years and is in various stages of reverting to woodland or is used for housing developments. Extensive areas (Madison, Chatham, and Florham Park) are in residential, commercial, and industrial developments. Urban land is used as building sites and for other nonfarm uses.

Soils Formed in Organic Deposits, Glacial Lake Sediment, or Glacial Outwash

The associations in this group occur throughout the county. They consist of wet organic soils, wet clayey soils, and wet or dry gravelly sandy loams. These soils are underlain by stratified glacial outwash or lacustrine sediment and are in basins, on low plains, or on terraces.

6. Riverhead-Urban land-Pompton association

Deep, well drained to somewhat poorly drained, nearly level to strongly sloping gravelly sandy loams and sandy loams that overlie stratified outwash sand and gravel; on outwash plains and terraces

The soils in this association formed in gravelly sandy loam or loamy sand glacial outwash. The outwash is derived mostly from granitic gneiss, red to brown shale and sandstone, and basalt. Bedrock is below a depth of 10 feet.

This association covers 12 percent of the county. It is 40 percent Riverhead soils, 25 percent Urban land-Riverhead complex, 10 percent Pompton soils, and 25 percent minor soils.

Riverhead soils are on terraces and outwash plains. These soils are nearly level to strongly sloping and well drained. The areas of Urban land have been cut, filled, smoothed, or otherwise mixed during construction. Most of the areas are covered by buildings and pavement. Most of the soils in the remaining open spaces have been reworked to the extent that the original profile cannot be identified. Pompton soils are on terraces and outwash plains. These soils are nearly level to gently sloping and somewhat poorly drained.

Minor soils are in the Preakness, Otisville, Parsippany, Boonton, and Adrian series and the Preakness series, dark surface variant. Preakness soils and the Preakness dark surface variant are in depressions on terraces and outwash plains. Otisville soils are on gently rolling high terraces. Parsippany soils are in old glacial lake basins. Boonton soils are on ridgetops, side slopes, and hills. Adrian soils are in depressions and low areas near streams. Isolated knobs of excessively drained coarse-textured soils are also present.

The soils in this association are limited for farming and community development by inadequate drainage in low areas, the hazard of erosion on sloping soils, and coarse texture. The wet areas and the coarse-textured soils are severely limited for onsite disposal of septic tank effluent.

This association is well suited to farming and to community development.

Most of this association was once cleared and used extensively for vegetables and nursery crops, but now it is idle or is used for residential, commercial, and industrial purposes. In the western part of the county and in the Berkshire Valley, areas of this association are mostly woodland. This association is a source of sand, gravel, and road fill. Pit operations are extensive in the northwestern part of Mount Olive Township. Near Succasunna and Pequannock, sand and gravel have been mixed by means of dredging, leaving large ponds or lakes. Urban land is used as building sites and for other nonfarm uses.

7. Carlisle-Parsippany-Preakness association

Deep, poorly drained and very poorly drained, nearly level mucks, silt loams, and sandy loams that overlie stratified lacustrine sand, silt, and clay or stratified outwash sand and gravel; in depressions or along low-gradient streams

This association consists of organic and mineral soils. The organic soils formed in partly decayed remains of herbaceous and woody plants in deposits 6 feet or more deep. The mineral soils formed in stratified clayey or sandy loam glacial outwash. Bedrock is below a depth of 10 feet.

This association covers 4 percent of the county. It is 50 percent Carlisle soils, 30 percent Parsippany soils, 10 percent Preakness soils, and 10 percent minor soils.

Carlisle soils are in depressions or along low-gradient streams. These are nearly level, very poorly drained, dark-colored organic soils. Parsippany soils are in the basin formerly occupied by Glacial Lake Passaic. They are nearly level, poorly drained mineral soils. Preakness soils are in depressions on terraces and outwash plains. These soils are nearly level, poorly drained sandy loams.

Minor soils in this association are in the Adrian and Biddeford series and the Preakness series, dark surface variant. Also included are areas of Muck, shallow to clay or shallow to loam. Adrian soils are in depressions and low areas near streams. The Preakness dark surface variant is in depressions on terraces and outwash plains. Biddeford soils are in depressions, along streams, and in old meander scars in the basin formerly

occupied by Glacial Lake Passaic. Muck is commonly around bogs and swamps.

This association is severely limited by poor to very poor drainage and by the organic soils.

If drained, the soils in this association are well suited to vegetables and other specialty crops. They are poorly suited to community development. They are suited to open-space activities.

This association is used mostly for trees and marsh plants.

8. Parsippany-Biddeford-Whippany association

Deep, somewhat poorly drained to very poorly drained, nearly level and gently sloping silt loams that overlie stratified lacustrine sand, silt, and clay; on broad lowlands

The soils in this association formed in moderately fine textured glacial outwash 3 feet or more thick over loamy to gravelly and sandy outwash several feet thick. Bedrock is below a depth of 10 feet.

This association covers 5 percent of the county. It is 45 percent Parsippany soils, 15 percent Biddeford soils, 15 percent Whippany soils, and 25 percent minor soils.

Parsippany soils are in the basin formerly occupied by Glacial Lake Passaic. They are nearly level and poorly drained. Biddeford soils are in depressions, along streams, and in old meander scars of the basin formerly occupied by Glacial Lake Passaic. These soils are nearly level and very poorly drained. Whippany soils are on slight elevations or gently sloping peripheral areas of the basin formerly occupied by Glacial Lake Passaic. These soils are nearly level to gently sloping and somewhat poorly drained.

Minor soils are in the Adrian, Carlisle, Pompton, Riverhead, and Preakness series. Also included are areas of Muck. Adrian and Carlisle soils and areas of Muck are in depressions and low areas near streams. Pompton, Riverhead, and Preakness soils are on terraces and outwash plains; Riverhead soils are well drained, Pompton soils are somewhat poorly drained, and Preakness soils are poorly drained.

The soils in this association are limited for farming and most community development by very poor to somewhat poor drainage, clayey texture, and frequent flooding (fig. 4).

This association is poorly suited to farming and most community development. It is well suited to habitat for waterfowl and associated wetland wildlife.

About half of the areas of this association are woodland. Most of the rest has been cleared and cultivated. In recent years, extensive areas have become idle and are now part of the Great Swamp National Wildlife Refuge.

Soils Formed in Old Glacial Deposits or in Material Weathered from Bedrock

The associations in this group are in the southern and southwestern parts of the county. The soils are dominantly loamy and deeply weathered, and they have more clay in the subsoil than in the surface layer or in the substratum. The substratum is weathered residuum or old glacial deposits. These soils are on uplands and in valleys.

9. Neshaminy-Ellington, loamy subsoil variant, association

Deep, well drained to somewhat poorly drained, gently sloping to steep fine sandy loams, gravelly silt loams, and very stony silt loams that overlie basalt or shale; on uplands

The soils in this association formed in material weathered in place from basalt bedrock or in fine sandy loam or loam sediment underlain at a depth of 40 inches or more by material weathered from the underlying rock. Rock is at the surface on steep slopes and ranges to a depth of more than 10 feet.

This association covers 2 percent of the county. It is 40 percent Neshaminy soils; 30 percent Ellington soils, loamy subsoil variant; and 30 percent minor soils.

Neshaminy soils are on the top and sides of ridges. These soils are gently sloping to steep and well drained. The Ellington loamy subsoil variant is on the sides of ridges in the basin formerly occupied by Glacial Lake Passaic. These soils are gently sloping to steep and moderately well drained to somewhat poorly drained.

Minor soils in this association are in the Penn, Pompton, and Riverhead series. Penn soils are on hills. Pompton and Riverhead soils are on terraces and outwash plains. Rock outcrop is also present.

The soils in this association are limited for farming and community development by steep slopes, the hazard of erosion, shallowness to bedrock in steep soils, stoniness, and seepage to the surface in steep soils, in cuts and excavations, and into foundations.

This association is poorly suited to farming and to most community development. It is suited to open-space activities and to wildlife habitat.

About half of the areas of this association are woodland. Most of the rest is in pasture, field crops, and nurseries. A small part has been used for residential development.

10. Penn-Reaville, deep variant-Urban land association

Deep and moderately deep, well drained to somewhat poorly drained, nearly level to steep shaly silt loams that overlie shale; on uplands

The soils in this association formed in shaly silt loam material weathered in place from shale bedrock. Shale bedrock is generally at a depth of 2 to 4 feet, but in steep to very steep soils it is above a depth of 20 inches.

This association covers 2 percent of the county. It is 50 percent Penn soils; 10 percent Reaville soils, deep variant; 10 percent Urban land-Penn complex; and 30 percent minor soils.

Penn soils are on low hills in the Passaic basin and in the valley of North Branch Raritan River and Gladstone Brook. These soils are gently sloping to steep, well drained, and moderately deep over shale bedrock. The Reaville deep variant is in drainageways, on gentle hills, and in seep spots. These soils are nearly level to

Figure 4.—**Stirling area during 1958 flood. Flooding covers nearly all Parsippany and Biddeford soils. Most of Stirling is on Penn soils, which did not flood. Recent construction has extended onto Whippany and Parsippany soils where hazard of flooding is greater.**

gently sloping, moderately well drained and somewhat poorly drained, and deep. The areas of Urban land have been cut, filled, smoothed, or otherwise mixed during construction. Most of the areas are covered by buildings and pavement. Most of the soils in the remaining open spaces have been reworked to the extent that the original profile cannot be identified.

Minor soils are in the Klinesville, Neshaminy, Riverhead, Whippany, and Parsippany series and the Ellington series, loamy subsoil variant. Klinesville soils are shallow and are on steep valley escarpments. Neshaminy soils and the Ellington loamy subsoil variant are on the tops and sides of ridges. Riverhead soils are on terraces and outwash plains. Whippany and Parsippany soils are in the basin formerly occupied by Glacial Lake Passaic.

The soils in this association are limited by shallowness to bedrock, steep slopes, and wetness.

This association is suited to farming and to community development.

Most areas of this association are woodland or pasture; some areas are cropped. Some small areas are used for residential and commercial development. Urban land is used as building sites and for other nonfarm uses.

11. Califon-Annandale-Cokesbury association

Deep, well drained to poorly drained, nearly level to strongly sloping loams, gravelly loams, very stony loams, and extremely stony loams that overlie granitic gneiss; on uplands

The soils in this association formed in deeply weathered loamy glacial till. The till is derived mostly from granitic gneiss. Bedrock is below a depth of 10 feet in most areas.

This association covers 4 percent of the county. It is 40 percent Califon soils, 30 percent Annandale soils, 25 percent Cokesbury soils, and 5 percent minor soils.

Califon soils are in depressions and waterways or in seepage areas at the base of slopes. These soils are nearly level to strongly sloping and moderately well drained to somewhat poorly drained. They have a fragipan in the lower part of the profile. Annandale soils are generally on ridgetops. These soils are gently sloping to strongly sloping and well drained. They have a fragipan in the lower part of the subsoil. Cokesbury soils are in drainageways, depressions, and areas at the base of steeper slopes. These soils are nearly level to gently sloping and poorly drained. They have a fragipan in the lower part of the subsoil.

Minor soils are in the Parker, Edneyville, and Bartley series. Parker and Edneyville soils are on the tops and sides of ridges. Bartley soils are on terraces adjacent to flood plains.

The soils in this association are limited by somewhat poor or poor drainage, the hazard of erosion on strongly sloping soils, and slow permeability in the fragipan.

This association is well suited to general farming, dairy farming, and most community development (fig. 5). It is well suited to open-space activities and to wildlife habitat.

More than half of this association has been cleared and farmed. The poorly drained and somewhat poorly drained Cokesbury and Califon soils support extensive areas of woodland.

12. Edneyville-Parker-Califon association

Deep, excessively drained to somewhat poorly drained, gently sloping to steep gravelly loams, very gravelly sandy loams, very stony loams, and extremely stony sandy loams that overlie granitic gneiss; on uplands

The soils in this association formed in granitic material weathered in place from bedrock or moved a short distance and redeposited in waterways. Bedrock is below a depth of 10 feet in most areas but crops out in a few places, particularly in steep soils.

This association covers 15 percent of the county. It is 50 percent Edneyville soils, 40 percent Parker soils, 5 percent Califon soils, and 5 percent minor soils.

Edneyville soils are on the tops and sides of ridges. These soils are gently sloping to steep and well drained. Parker soils are on the tops and sides of ridges. These soils are gently sloping to steep, excessively drained, and very gravelly. Califon soils are in depressions, drainageways, and seepage areas at the base of slopes. These soils are nearly level to strongly sloping and moderately well drained to somewhat poorly drained. They have a fragipan in the lower part of the profile.

Minor soils are in the Annandale, Cokesbury, and Bartley series and the Califon series, friable subsoil variant. Annandale soils are on ridgetops. Cokesbury soils and the Califon friable subsoil variant are in drainageways and depressions and at the base of steep slopes. Bartley soils are on terraces adjacent to flood plains.

***Figure 5.*—Contour cultivation on Annandale soils. Wooded areas are steeper Edneyville and Parker soils. Urbanization is spreading into wooded and farmed areas.**

The well drained and excessively drained soils in this association are limited for farming and community development by coarse fragments, steep slopes, and the hazard of erosion.

This association, particularly the gently sloping soils, is suited to farming and most community development. The strongly sloping to steep soils are not well suited to farming and intensive community development, but they are well suited to open space and wildlife habitat.

Most of this association has been cleared for farming. The steep and very stony to extremely stony soils are wooded. Some old fields are now in trees, either by natural seeding or by planting of pines and other conifers.

13. Parker-Edneyville association

Deep, excessively drained and well drained, steep to very steep very gravelly sandy loams, gravelly loams, and extremely stony sandy loams that overlie granitic gneiss; on uplands

The soils in this association formed in gravelly to extremely stony material weathered in place from bedrock. Bedrock is as shallow as 4 feet but is typically more than 10 feet deep.

This association covers 5 percent of the county. It is 50 percent Parker soils, 40 percent Edneyville soils, and 10 percent minor soils.

Parker and Edneyville soils are on the top and sides of ridges. The Parker soils are steep to very steep, excessively drained, and very gravelly. The Edneyville soils are steep and well drained.

Minor soils are in the Califon, Cokesbury, Netcong, and Bartley series. Califon and Cokesbury soils are in drainageways and depressions. Netcong soils are on rolling uplands. Bartley soils are on terraces adjacent to flood plains.

The soils in the association are limited by steep to very steep slopes, stoniness, and rock outcrops.

This association is unsuitable for farming and is severely limited for intensive community development. It is suited to open-space activities and to protection of watershed.

Most areas of this association are woodland, but a small part has been cleared and is used for pasture.

14. Bartley-Turbotville-Cokesbury association

Deep, moderately well drained to poorly drained, nearly level to strongly sloping loams and gravelly loams that overlie limestone or granitic gneiss; on terraces

The soils in this association formed in deeply weathered glacial till or colluvium of mixed mineralogy. The till and colluvium are derived largely from granitic gneiss. Bedrock is generally below a depth of 10 feet.

This association covers 5 percent of the county. It is 25 percent Bartley soils, 25 percent Turbotville soils, 20 percent Cokesbury soils, and 30 percent minor soils.

Bartley soils are on terraces adjacent to flood plains. These soils are gently sloping to strongly sloping and moderately well drained. They have a fragipan in the lower part of the subsoil. Turbotville soils are in drainageways and depressions in the uplands and on terraces. These soils are nearly level to gently sloping and somewhat poorly drained. They have a fragipan in the lower part of the subsoil. Cokesbury soils are in drainageways and depressions and at the base of steep slopes. These soils are nearly level to gently sloping and poorly drained. They have a fragipan in the lower part of the subsoil.

Minor soils are in the Edneyville, Califon, and Washington series. Also included are areas of Alluvial land and Alluvial land, wet. Edneyville soils are on the top and sides of ridges. Califon soils are in drainageways and depressions and at the base of slopes. Washington soils are on terraces adjacent to flood plains. Alluvial land is on flood plains.

The soils in this association are limited by inadequate drainage.

The soils in this association are among the best in the county for farming. The association is also suited to community development. Poor drainage in Cokesbury soils is a severe limitation to community development.

Most of this association is in crops and pasture. Small areas of poorly drained soils, generally along streams, are woodland.

Descriptions of the Soils

This section describes the soil series and mapping units in Morris County. Each soil series is described in detail, and then, briefly, each mapping unit in that series. Unless specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. The profile described in the series is representative of mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the maping unit or they are differences that are apparent in the name of the mapping unit. Color terms are for moist soils unless otherwise stated. Reaction is for untreated soils. Limed soils are less acid, in places to a depth of 2 or 3 feet.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Rock outcrop, for example, does not belong to a soil series, but nevertheless is listed in alphabetic order along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each

description of a mapping unit is the capability unit in which the mapping unit has been placed.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*10*).

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Adrian muck	3,450	1.2	Netcong gravelly sandy loam, 3 to 8 percent slopes	4,350	1.5
Alluvial land	3,000	1.0	Netcong gravelly sandy loam, 8 to 15 percent slopes	2,750	.9
Alluvial land, wet	1,900	.6	Otisville gravelly loamy sand, 3 to 15 percent slopes	2,650	.9
Annandale gravelly loam, 3 to 8 percent slopes	5,450	1.8	Otisville gravelly loamy sand, 15 to 25 percent slopes	580	.2
Annandale gravelly loam, 8 to 15 percent slopes	1,200	.4	Parker gravelly sandy loam, 3 to 15 percent slopes	9,600	3.2
Bartley loam, 0 to 3 percent slopes	680	.2	Parker very gravelly sandy loam, 15 to 25 percent slopes	2,700	.9
Bartley loam, 3 to 8 percent slopes	2,800	.9	Parker-Edneyville extremely stony sandy loams, 3 to 15 percent slopes	16,900	5.6
Bartley gravelly loam, 8 to 15 percent slopes	580	.2	Parker-Edneyville extremely stony sandy loams, 15 to 25 percent slopes	8,600	2.9
Biddeford silt loam	2,950	1.0	Parker-Rock outcrop complex, 20 to 35 percent slopes	6,800	2.3
Boonton gravelly loam, 3 to 8 percent slopes	1,100	.4	Parsippany silt loam	2,500	.8
Boonton gravelly loam, 8 to 15 percent slopes	1,250	.4	Parsippany silt loam, sandy loam substratum	8,050	2.7
Boonton and Haledon extremely stony soils, 8 to 15 percent slopes	650	.2	Pattenburg gravelly loam, 3 to 8 percent slopes	450	.1
Califon loam, 0 to 3 percent slopes	1,300	.4	Pattenburg gravelly loam, 8 to 15 percent slopes	340	.1
Califon loam, 3 to 8 percent slopes	4,050	1.4	Penn shaly silt loam, 3 to 8 percent slopes	2,000	.7
Califon loam, 8 to 15 percent slopes	950	.3	Penn shaly silt loam, 8 to 15 percent slopes	1,250	.4
Califon gravelly loam, 3 to 8 percent slopes	1,150	.4	Penn-Klinesville shaly silt loams, 15 to 25 percent slopes	430	.1
Califon very stony loam, 2 to 8 percent slopes	3,700	1.2	Pits, sand and gravel	1,370	.5
Califon very stony loam, 8 to 15 percent slopes	800	.3	Pompton sandy loam, 0 to 3 percent slopes	530	.2
Califon loam, friable subsoil variant, 3 to 8 percent slopes	1,450	.5	Pompton sandy loam, 3 to 8 percent slopes	3,600	1.2
Carlisle muck	7,900	2.6	Preakness sandy loam, 0 to 4 percent slopes	3,400	1.1
Cokesbury gravelly loam, 0 to 3 percent slopes	2,150	.7	Preakness sandy loam, dark surface variant	1,200	.4
Cokesbury gravelly loam, 3 to 8 percent slopes	1,600	.5	Reaville shaly silt loam, deep variant, 0 to 5 percent slopes	780	.3
Cokesbury extremely stony loam, 0 to 8 percent slopes	6,850	2.3	Ridgebury very stony loam, 0 to 3 percent slopes	2,250	.7
Edneyville gravelly loam, 3 to 8 percent slopes	9,300	3.1	Ridgebury extremely stony loam, 3 to 10 percent slopes	3,900	1.3
Edneyville gravelly loam, 8 to 15 percent slopes	6,550	2.2	Riverhead gravelly sandy loam, 0 to 3 percent slopes	270	.1
Edneyville gravelly loam, 15 to 25 percent slopes	2,400	.8	Riverhead gravelly sandy loam, 3 to 8 percent slopes	4,600	1.5
Ellington fine sandy loam, loamy subsoil variant, 3 to 8 percent slopes	770	.3	Riverhead gravelly sandy loam, 8 to 15 percent slopes	2,050	.7
Ellington fine sandy loam, loamy subsoil variant, 8 to 15 percent slopes	840	.3	Riverhead gravelly sandy loam, neutral variant, 2 to 8 percent slopes	1,150	.4
Ellington fine sandy loam, loamy subsoil variant, 15 to 25 percent slopes	230	.1	Rockaway gravelly sandy loam, 3 to 8 percent slopes	2,150	.7
Haledon silt loam, 3 to 8 percent slopes	4,450	1.5	Rockaway gravelly sandy loam, 8 to 15 percent slopes	1,150	.4
Haledon silt loam, 8 to 15 percent slopes	780	.3	Rockaway very stony sandy loam, 3 to 15 percent slopes	24,000	8.0
Hibernia stony loam, 3 to 15 percent slopes	9,800	3.3	Rockaway extremely stony sandy loam, 15 to 25 percent slopes	10,600	3.5
Hibernia very stony loam, 15 to 25 percent slopes	600	.2	Rockaway-Rock outcrop complex, 3 to 15 percent slopes	7,250	2.4
Holyoke rocky silt loam, 5 to 15 percent slopes	760	.3	Rockaway-Rock outcrop complex, 15 to 25 percent slopes	5,900	2.0
Holyoke-Rock outcrop complex, 15 to 35 percent slopes	730	.2	Rockaway-Rock outcrop complex, 25 to 45 percent slopes	2,700	.9
Klinesville shaly silt loam, 25 to 35 percent slopes	260	.1	Rock outcrop	500	.2
Made land, sanitary land fill	660	.2	Rock outcrop-Rockaway complex, steep	7,800	2.6
Minoa silt loam, 0 to 3 percent slopes	280	.1	Turbotville loam, 0 to 3 percent slopes	1,400	.5
Minoa silt loam, 3 to 8 percent slopes	840	.3	Turbotville loam, 3 to 8 percent slopes	2,650	.9
Muck, shallow over clay	970	.3			
Muck, shallow over loam	960	.3			
Neshaminy gravelly silt loam, 3 to 8 percent slopes	950	.3			
Neshaminy gravelly silt loam, 8 to 15 percent slopes	1,450	.5			
Neshaminy very stony silt loam, 15 to 25 percent slopes	390	.1			

TABLE 1.—*Approximate acreage and proportionate extent of the soils*—Continued

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Urban land	6,200	2.1	Urban land-Rockaway complex, moderately steep	650	0.2
Urban land, wet	480	.2	Urban land-Whippany complex	970	.3
Urban land-Edneyville complex	1,450	.5	Washington loam, 0 to 8 percent slopes	1,150	.4
Urban land-Haledon complex	2,800	.9	Whippany silt loam, 0 to 3 percent slopes	550	.2
Urban land-Neshaminy complex	550	.2	Whippany silt loam, 3 to 8 percent slopes	1,100	.4
Urban land-Penn complex	630	.2	Whippany silt loam, sandy loam substratum, 0 to 3 percent slopes	400	.1
Urban land-Preakness complex	530	.2	Whippany silt loam, sandy loam substratum, 3 to 8 percent slopes	1,000	.3
Urban land-Riverhead complex	9,600	3.2	Whitman very stony loam	930	.3
Urban land-Rockaway complex, gently sloping and sloping	8,500	2.8	Total	299,520	100.0

Adrian Series

The Adrian series consists of nearly level, very poorly drained organic soils that are underlain by sandy deposits at a depth of 16 to 50 inches. These soils are in low positions. In the northern half of the county, they are in small depressions or kettles; in the southern half, they are in large areas.

In a representative profile the surface layer is black, highly decomposed muck about 12 inches thick. Below this, and extending to a depth of about 42 inches, is very dark brown and dark-brown, fibrous and decomposed muck. The substratum to a depth of 60 inches is gray loamy sand.

Permeability is rapid, and available water capacity is high. The water table is at the surface most of the time. Most large areas of Adrian muck are near streams, and they are subject to stream overflow. The soils are unstable under load, are compressible, and subside if they are drained.

If Adrian soils are farmed, they require drainage and protection from flooding. Drainage outlets are typically not available or are costly to obtain. The soils have potential for intensive production of vegetables or specialty crops but are little used in Morris County because of drainage costs. In most places the present vegetation is trees, mainly red maple and elm.

Representative profile of Adrian muck, one-fourth mile east of Pleasant Hill Road, 50 feet from southern edge of bog:

Oa1—0 to 12 inches, black (10YR 2/1, broken face and rubbed) muck (sapric material); 10 percent fiber, less than 5 percent rubbed; weak, medium, granular structure; sticky; 30 percent, by weight, organic matter; mineral part is clay loam; medium acid; clear, wavy boundary.

Oa2—12 to 36 inches, very dark brown (7.5YR 2/2, broken face and rubbed) muck (sapric material), on exposure to air, color changes rapidly to black (10YR 2/1); 60 percent fiber, 10 percent rubbed; sodium-pyrophosphate-extract color very dark grayish brown (10YR 3/2) massive; slightly sticky; 10 percent woody coarse fragments ¼ inch to 3 inches in size along minimum dimension; medium acid; clear, wavy boundary.

Oe1—36 to 42 inches, dark-brown (7.5YR 3/2) hemic material, black (5YR 2/1) rubbed; 60 percent fiber, 15 percent rubbed; sodium-pyrophosphate-extract color very pale brown (10YR 7/3); massive; nonsticky; medium acid; abrupt, wavy boundary.

IIC—42 to 60 inches, gray (10YR 5/1) loamy sand; single grained; loose; medium acid.

The surface layer ranges from black (N 2/0) to very dark grayish brown (10YR 3/2), is sapric or hemic material, and generally is 50 to 70 percent mineral material that ranges from loam to clay. The subsurface and lower organic layers are dominantly sapric material but generally have a thin layer of hemic material. The combined thickness of the hemic layers is less than 10 inches. Reaction of the subsurface and lower organic layers is medium acid or slightly acid. Color is 5YR to 10YR in hue, 2 to 3 in value, and 1 to 3 in chroma. Broken-face and rubbed colors are similar but often differ by one or two units. Fibers throughout the profile are derived dominantly from herbaceous plants, but woody fragments and fibers make up as much as 50 percent of some layers in many places. Depth to the sandy substratum ranges from 16 to 50 inches and averages about 30 inches. The substratum is sand or loamy sand. It is generally gray but is mottled in many places. In some places the substratum is darkened by organic matter for as much as 6 inches, where it contacts the muck layer. Depth to bedrock is 10 feet or more.

Adrian soils are near Carlisle, Preakness, and Pompton soils and Muck. They have a thinner organic deposit than Carlisle soils. They contain more organic matter than Preakness and Pompton soils. They have a coarser textured IIC horizon than Muck.

Adrian muck (Ad).—This nearly level soil has a permanent high water table and is ponded or flooded in winter and in spring.

Included with this soil in mapping are small areas of Carlisle, Parsippany, Preakness, and Biddeford soils and Muck, shallow over clay.

Where this soil is deeper than is typical, it has potential for farming. However, high land values because of urban expansion make it unlikely that extensive areas will be developed for farming. This soil is severely limited for most community development. It is used as sites for dug ponds. Capability unit VIIw-41.

Alluvial Land

Alluvial land consists of water-laid sediment along streams in all parts of the county. Drainage is variable. The material is variable.

This land type has a permanent high water table and is flooded annually.

The hazard of flooding makes this land type poorly suited to most uses. The areas generally are not farmed. Some areas are used for pasture, and some are woodland. Other areas are used for residential, commercial, and industrial development.

Alluvial land (Ae).—This land type consists of poorly drained, somewhat poorly drained, and moderately well drained alluvial soils that are generally 3 to 8 feet above the normal level of streams. These soils are extensive on narrow flats, in slightly higher areas near the margins of stream flood plains, and on natural levees on the flood plains. The water table is at a depth of 1 foot to 4 feet most of the year but rises abruptly after heavy rains. These soils are flooded on an average of once a year. In the northern and central parts of the county, flooding seldom lasts more than 12 to 24 hours, but near Long Valley, Butler, and Stirling, flooding commonly lasts 1 to 2 days. Available water capacity is moderate to high, especially in the upper 2 to 3 feet.

This mapping unit consists of stratified material of contrasting texture, composition, and drainage. The underlying material is generally stratified coarse sand, gravel, cobbles, and stones and loamy or mucky layers of variable thickness. Coarse fragments are derived mainly from granitic gneiss or weathered shale. Bedrock is generally below a depth of 6 feet.

In many places Alluvial land is near Alluvial land, wet. The water table in Alluvial land is not so high throughout the year as that in Alluvial land, wet. On terraces and uplands Alluvial land is also near Riverhead, Pompton, Preakness, Parsippany, Whippany, and other soils. Alluvial land does not have the distinct horizonation that is common in those soils, which formed on higher positions than Alluvial land.

Because of the hazard of flooding and the probability of severe damage, these soils are not generally farmed and are commonly used for parks. Most areas were formerly cleared and used for pasture, but large areas are reverting to woodland. In some areas of intense development, such as the towns of Dover and Pequannock, these soils are used as residential, commercial, and industrial sites; however, damage from floods is generally extensive. Capability unit VIw-86.

Alluvial land, wet (Am).—This land type consists of very poorly drained alluvial soils. Areas are generally smaller than 10 acres. The soils are in depressions and serpentive meander scars on flood plains, about 1 foot to 4 feet above the normal level of streams. They consist of various materials eroded from nearby uplands or transported from a distance by the adjacent streams. The water table is at or near the surface most of the time. These soils are flooded at least once a year and, because of their low position, are ponded by runoff for long periods. Available water capacity is moderate or high.

The material is variable. The soils are generally underlain by gravel or sand. Bedrock is generally below a depth of 6 feet.

Alluvial land, wet, is near Alluvial land. The water table in Alluvial land, wet, is higher throughout the year than in Alluvial land.

These soils are severely limited for farming and community development by the hazard of flooding and the high water table (fig. 6). Reeds and cattails cover the soils before hardwoods seed in. Limited areas near Mine Hill, Dover, and Pequannock have been filled and used for residential, commercial, or industrial sites. Capability unit VIw-46.

Annandale Series

The Annandale series consists of deep, gently sloping to strongly sloping, well-drained soils that have a weakly developed fragipan in the lower part of the subsoil. These soils are extensive on broad undulating ridgetops. They formed in strongly weathered glacial till that is mostly granitic gneiss, and they contain subangular gravel and cobbles and some stones in nearly all places. Most of the coarse fragments are weathered, but some are hard and relatively unweathered.

In a representative profile the surface layer is dark-brown gravelly loam about 11 inches thick. The upper part of the subsoil is yellowish-brown gravelly loam about 6 inches thick. The middle is strong-brown gravelly clay loam about 15 inches thick, and the lower part is a firm and brittle fragipan of strong-brown gravelly sandy loam about 12 inches thick. Between depths of 44 and 76 inches, the substratum is strong-brown gravelly sandy loam, and between depths of 76 and 108 inches it is yellowish-red weathered granitic gneiss of sandy loam texture.

Permeability is moderate above and below the fragipan and slow in the fragipan. Depth to the water table is generally more than 10 feet, but during brief periods late in winter and early in spring, particularly following early thaws and periods of heavy rain, free water is perched on top of the fragipan. This water tends to move laterally, seeping to the surface on steep slopes and flowing from excavations. The fragipan restricts the growth of plant roots. The available water capacity is moderate; it is sufficient in most years for most crops. Water stored below the fragipan is generally not available for use by plants.

Annandale soils are suited to general crops and to most specialized crops grown in the county.

Representative profile of Annandale gravelly loam, 3 to 8 percent slopes, in an idle field, 50 yards southeast of Naughright Road, three-fourths of a mile north of Flocktown Road, 25 yards north of the powerline:

Ap—0 to 11 inches, dark-brown (10YR 4/3) gravelly loam; strong, medium and coarse, granular structure; very friable; many roots; 15 percent angular gravel, 2 percent angular cobbles, mainly granitic gneiss; medium acid; abrupt, smooth boundary. 7 to 11 inches thick.

B1—11 to 17 inches, yellowish-brown (10YR 5/8) gravelly heavy loam; weak, medium, angular blocky structure; friable; common roots; thick clay films in some pores and thin, discontinuous, dull clay films in patches on ped faces; 15 percent angular gravel, 2 percent angular granitic gneiss cobbles; slightly acid; clear, wavy boundary. 5 to 12 inches thick.

B2t—17 to 32 inches, strong-brown (7.5YR 5/8) gravelly clay loam; weak, medium, angular blocky structure; friable; common roots; discontinuous, glossy, yellowish-red (5YR 5/8) clay films on ped faces and in some channels and voids; 15 percent angular gravel, 2 percent angular cobbles, less than 1 per-

Figure 6.—**Flood damage to road on Alluvial land, wet, which is subject to frequent flooding.**

cent angular stones, mainly granitic gneiss; slightly acid; clear, wavy boundary. 12 to 26 inches thick.

Bx—32 to 44 inches, strong-brown (7.5YR 5/8) gravelly sandy loam; weak, subangular blocky structure or massive; firm and brittle; few roots; thick patchy clay films on ped faces; 25 percent angular gravel, 5 percent angular cobbles, less than 1 percent angular granitic gneiss stones; strongly acid; gradual, wavy boundary. 6 to 13 inches thick.

C1—44 to 76 inches, strong-brown (7.5YR 5/8) gravelly sandy loam; massive; friable; 25 percent angular gravel, 5 percent angular cobbles, less than 1 percent angular granitic gneiss stones; strongly acid; abrupt, wavy boundary. 25 to 35 inches thick.

IIC2—76 to 108 inches, yellowish-red (5YR 5/8) sandy loam saprolite; massive; friable; less than 10 percent coarse fragments of angular granitic gneiss gravel, cobbles, and stones; strongly acid.

The solum ranges from 40 to 60 inches in thickness. Depth to the fragipan is 24 to 36 inches. Depth to bedrock ranges from 6 to 10 feet or more. The upper part of the solum contains 5 to 20 percent coarse fragments of angular gravel, cobbles, and stones. The content of coarse fragments increases with increasing depth. Granitic gneiss is always dominant, but in places these soils include fine earth and coarse fragments derived from quartzite conglomerate, sandstone, and chert. In areas that are not limed, reaction is medium acid to strongly acid.

The A horizon is 10YR in hue, 3 or 4 in value, and 2 or 3 in chroma.

The B horizon above the fragipan has a hue of 7.5YR or 10YR, a value of 5 or 6, and a chroma of 6 to 8. Contrasting colors occur in association with weathered granules and gravel and faint mottling near the bottom of this horizon. The texture ranges from loam to clay loam and their gravelly analogs.

The fragipan is similar to the rest of the B horizon in color but is slightly paler. The upper part of the fragipan has very faint pale mottling in some places. It is commonly sandy loam but ranges to clay loam and is gravelly in places. It is slightly firm to very firm and brittle.

The C horizon ranges from yellowish-red (5YR 5/8) to light yellowish-brown (10YR 6/4) sandy loam to clay loam and their gravelly analogs.

Annandale soils are generally associated with Parker, Edneyville, Califon, and Cokesbury soils. They have a higher content of clay in the B horizon and contain fewer coarse fragments than Parker soils. They are similar to Edneyville soils, but Edneyville soils lack a fragipan. Annandale soils lack the low-chroma mottles that are common in Califon soils and the low-chroma matrix color that is common in Cokesbury soils.

Annandale gravelly loam, 3 to 8 percent slopes (AnB).—This soil has the profile described as representative of the series. Included in mapping are areas of less gravelly Annandale soils and Califon, Cokesbury, Edneyville, and Parker soils.

This soil is well suited to farming and community development. The principal properties that affect the use of this gently sloping soil are adequate surface drainage, lateral seepage of water on top of the fragipan, and slow permeability in the fragipan. The hazard of erosion is only moderate, and practices to control erosion on farmland can be easily applied. If crop rotation, contour cultivation, and in places stripcropping on long slopes are used, cultivated crops can be grown year after year without excessive erosion (fig. 7).

Figure 7.—**Stripcropping on an Annandale soil to reduce erosion and control runoff.**

Drainage generally is not needed on Annandale soils, but in places it is needed on the included soils that are not well drained. If this soil is used for special intensive purposes, drainage diversions or subsurface interceptor drains are needed in places. Because the firm fragipan in the lower part of the subsoil restricts the growth of roots, irrigation is needed, especially for high-value crops. Capability unit IIe-53.

Annandale gravelly loam, 8 to 15 percent slopes (AnC).—This soil has a profile similar to the one described as representative of the series, but the content of gravel is slightly higher.

Included with this soil in mapping are areas of Califon and Edneyville soils and cobbly or stony phases of Parker soils. In places these cobbly or stony areas are sufficiently abundant to affect the use and management of the soil. Unless the cobbles and stones are removed, they reduce the suitability of this soil for cultivated crops.

This soil is well suited to pasture, hay, and cultivated crops, but, because the soil is strongly sloping, the hazard of erosion is moderately high. Other properties that limit the use of this soil are slow permeability in the fragipan and lateral seepage of water on top of the fragipan. Deep cuts generally needed in the construction of roads or plot layouts for houses or other land-grading operations on the steeper slopes could result in further erosion because of the release of seepage water to the surface in these cuts. Drainage diversions or interceptor drains above such cuts are thus used frequently to assist in their stabilization. Other farmland conservation practices that are used to control erosion are contour cultivation, crop rotation, stripcropping, and diversions. Capability unit IIIe-53.

Bartley Series

The Bartley series consists of deep, nearly level to strongly sloping, moderately well drained soils on terraces in major valleys distinctly above the level of the flood plain. These soils have a slowly permeable, weakly developed, very firm fragipan. They formed in strongly weathered glacial till that was derived mainly from granitic material but contains some quartzite, shale, sandstone, conglomerate, and limestone. In most places the soils are underlain by noncavernous limestone bedrock that has open joints and fractures.

In a representative profile the surface layer is dark-

brown loam about 11 inches thick. The upper part of the subsoil is about 21 inches thick. In sequence from the top, the upper 5 inches is strong-brown loam, the middle 4 inches is yellowish-brown sandy clay loam, and the lower 12 inches is yellowish-brown clay loam. The lower part of the subsoil is a fragipan of mottled, yellowish-brown, very firm, dense sandy loam about 10 inches thick. The subsoil is about 10 percent gravel and cobbles. The substratum, which is between depths of about 42 and 88 inches, is variegated reddish-yellow, strong-brown, white, and very pale brown very fine sandy loam. Hard limestone bedrock is at a depth of 88 inches.

Permeability is moderate above and below the fragipan and slow in the fragipan, and free water is held in the soil above the fragipan. The water moves laterally, causing seepage at excavations. The fragipan also restricts the growth of plant roots. The surface layer is loamy and has a moderately high organic-matter content, which results in good tilth. The subsoil has sufficient clay to make it slightly plastic and enough sand and gravel so that it has good compaction characteristics, low compressibility, and low subsidence. It makes stable, slowly permeable compacted embankments. The available water capacity is moderate.

Bartley soils are well suited to crops. They are used extensively for general-purpose crops and pasture.

Representative profile of Bartley loam, 3 to 8 percent slopes, in the middle of a field, 400 yards southeast of Route 513 and 660 yards southwest of Long Valley:

Ap—0 to 11 inches, dark-brown (10YR 4/3) loam; weak and moderate, medium, granular structure; friable; 5 percent coarse fragments, mostly granitic pebbles, 2 millimeters to 5 centimeters in diameter; neutral; abrupt, smooth boundary. 8 to 11 inches thick.

B21t—11 to 16 inches, strong-brown (7.5YR 5/6) heavy loam; moderate, medium, subangular blocky structure; very friable; 10 percent coarse fragments, mostly 1 centimeter to 2 centimeters in size; yellowish-red (5YR 5/6), thick, glossy, discontinuous clay films on ped faces; neutral; gradual, wavy boundary. 4 to 10 inches thick.

B22t—16 to 20 inches, yellowish-brown (10YR 5/8) sandy clay loam; weak, medium and coarse, subangular blocky structure; friable; 10 percent coarse fragments; strong-brown (7.5YR 5/6) patchy clay films on faces of peds; slightly acid; gradual, wavy boundary. 4 to 10 inches thick.

B3t—20 to 32 inches, yellowish-brown (10YR 5/8) clay loam; few, fine, distinct, brown (10YR 5/3) mottles; weak, very thick, platy structure; firm; 10 percent coarse fragments; thick, glossy to dull, patchy clay films on horizontal faces of peds; some black (5YR 2/1) glossy stains; slightly acid; abrupt, wavy boundary. 0 to 16 inches thick.

Bx—32 to 42 inches, yellowish-brown (10YR 5/6) heavy sandy loam; few, fine, distinct, brown (10YR 5/3) mottles; weak, very thick, platy structure or massive; very firm, brittle; 10 percent coarse fragments that show a marked increase in the proportion of weathered limestone and chert chips; brown (7.5YR 4/4), thick, patchy clay films on horizontal faces of peds or fractures; neutral; abrupt, wavy boundary. 4 to 14 inches thick.

IIC—42 to 88 inches, variegated reddish-yellow (7.5YR 7/8), strong-brown (7.5YR 5/8), white (10YR 8/2), and very pale brown (10YR 8/3) very fine sandy loam; brownish stains infiltrate the matrix in the upper part; massive; friable; lower part retains some rock structure; neutral; clear, wavy boundary. 0 to 60 inches thick.

IIR—88 inches, hard limestone bedrock.

The solum ranges from 35 to 60 inches in thickness. Depth to the fragipan is 24 to 36 inches, and depth to bedrock is 6 to 10 feet or more. The content of gravel and cobbles ranges from 5 to 25 percent. These coarse fragments are dominantly angular granitic fragments in the upper part. The amount of limestone and sandstone increases with increasing depth. In areas that are not limed, reaction is slightly acid near the surface and neutral in the lower part of the B horizon.

The A horizon has a hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 or 3. It is loam or gravelly loam.

The Bt horizon lacks mottles above a depth of about 2 feet and is uniform in color. It has a hue of 7.5YR or 10YR, value of 5 to 7, and chroma of 6 to 8. This horizon is clay loam to heavy sandy loam and their gravelly analogs. In the lower part of the Bt and Bx horizons, at depths of 2 to 5 feet, the matrix color is the same, but both high- and low-chroma mottles occur. The mottles range from 5 to 7 in value and 1 to 3 or 6 to 8 in chroma.

The B horizon above the fragipan has weak to moderate, medium to coarse, subangular blocky structure but in places is weak platy in the lower part. The fragipan typically has weak, very coarse, prismatic structure parting to weak and strong, very thick, platy, but in places structure is weak or moderate, subangular blocky in the fragipan.

The C horizon ranges from sandy loam to loam and their gravelly analogs, mostly weathered till of granitic materials or residuum weathered from the underlying bedrock.

Bartley soils are associated with Turbotville, Riverhead neutral variant, Pattenburg, Edneyville, and Washington soils. Bartley, Washington, Turbotville, and Riverhead neutral variant soils that formed in mineralogically similar material. Bartley soils are more clayey and have less coarse sand than the Riverhead neutral variant. They lack the gray mottling in the upper part of the B horizon that is characteristic of Turbotville soils. They have brown and yellowish-brown mottles and a fragipan in the B horizon, which Washington soils lack. Bartley soils are less acid and have a fragipan, which is lacking in Edneyville soils. Bartley soils do not have the red, gravelly and shaly material that is common in Pattenburg soils.

Bartley loam, 0 to 3 percent slopes (BaA).—This soil is in wide, nearly level swales on terraces. Included in mapping are areas of Turbotville soils that make up about 25 percent of the mapping unit. Also included are small areas of Washington and Edneyville soils.

Runoff is slow. This soil receives runoff from adjacent, higher areas.

This soil is well suited to pasture, hay, corn, and vegetables. The dominant properties that affect the use of this nearly level soil are the loamy surface layer and the fragipan in the lower part of the subsoil. Drainage is not commonly critical for general farming. If this soil is used for intensive purposes, improved drainage is desirable. Drainage diversions and subsurface interceptor drains are used for both farm and suburban uses. Capability unit IIw-71.

Bartley loam, 3 to 8 percent slopes (BaB).—This soil has the profile described as representative of the series. Included in mapping are small areas of Washington and Turbotville soils. In a few widely spaced places, cobbles, stones, and boulders are sufficiently numerous to affect use and management. Also included east of Flanders in the vicinity of some sandstone pits are small areas of a sandy soil that has a white bleached layer of irregular thickness immediately beneath the surface layer.

This Bartley soil is well suited to farm and residential use. The hazard of erosion is moderate. Diversions and subsurface interceptor drains help to improve drainage. In addition, contour cultivation, a crop rotation, and stripcropping help to control erosion in farmed areas. In residential developments and recreational areas, early establishment of cover, such as lawns, has reduced erosion and runoff. Interceptor drains at the top of slopes or around foundations are also effective. Capability unit IIe-71.

Bartley gravelly loam, 8 to 15 percent slopes (BbC).—This soil has a profile similar to the one described as representative of the series, but it contains 15 to 20 percent gravel. Included in mapping are small areas of Washington and Edneyville soils and, in isolated spots, Turbotville soils. In small widely spaced areas cobbles, stones, and boulders are sufficiently numerous to affect the use and management of this soil.

This soil is well suited to pasture, hay, and cultivated crops. Because the soil is strongly sloping, the hazard of erosion is moderately severe. Other properties that limit the use of this soil are slow permeability in the fragipan and lateral seepage of water on top of the fragipan. The fragipan restricts the growth of roots, and water stored below the fragipan is not generally available for use by plants. Drainage is not generally critical for farming. Seepage is likely in excavations, and drainage diversions and interceptor drains above such cuts are used to help stabilize them. Other suitable conservation practices that help to control erosion are contour cultivation, crop rotation, stripcropping, and diversions. Capability unit IIIe-71.

Biddeford Series

The Biddeford series consists of deep, nearly level, very poorly drained soils. These soils are in depressions, along streams, and in old meander scars on the flat, nearly level bottom of the basin formerly occupied by glacial Lake Passaic. They formed in stratified, glacial lacustrine deposits and have a thin mantle of silty and mucky sediment washed from surrounding soils.

In a representative profile a layer of black muck about 8 inches thick overlies the surface layer of dark-gray silt loam about 6 inches thick. The upper part of the subsoil, about 4 inches thick, is light brownish-gray silt loam. Below this, and extending to a depth of about 36 inches, the subsoil is mottled, gray and pinkish-gray silty clay loam that is sticky and plastic when wet. The substratum to a depth of 52 inches is dark-brown silt loam that contains thin layers of sandy and clayey material.

Permeability is slow. The water table is at or above the surface most of the time, except during summer. These soils are frequently flooded. They have poor workability.

Undisturbed areas of Biddeford soils support swamp or marsh vegetation. Improved drainage is needed if the soils are used for crops or community development. Surface drainage by ditching and bedding systems are effective. Because of the low position of the soils and the lack of adequate outlets, drainage systems in many places are expensive and difficult to install.

Representative profile of Biddeford silt loam, in a wooded area, one-fourth mile south of Pine Brook Road, one-half mile east of Tom's Point, in Lincoln Park Borough:

O2—8 inches to 0, black (5YR 2/1, broken face and rubbed) highly decomposed muck; less than 5 percent fibers when rubbed; moderate, medium, granular structure; nonsticky; slightly acid; gradual, smooth boundary, 6 to 12 inches thick.

A1g—0 to 6 inches, dark-gray (10YR 4/1) silt loam; moderate, fine, granular structure; friable, nonsticky nonplastic; medium acid; gradual, wavy boundary. 3 to 16 inches thick.

B1g—6 to 10 inches, light brownish-gray (10YR 6/2) silt loam; weak, medium, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; most sand grains coated but clean in some pockets on ped faces; slightly acid; clear, smooth boundary. 0 to 6 inches thick.

IIB2g—10 to 36 inches, mottled gray (10YR 6/1) and pinkish-gray (7.5YR 6/2) heavy silty clay loam; weak, medium, subangular blocky structure; firm when moist, sticky and plastic when wet; many yellowish-red (5YR 5/6) speckles; slightly acid; abrupt, smooth boundary. 15 to 30 inches thick.

IIIC—36 to 52 inches, dark-brown (7.5YR 4/4) heavy silt loam that contains thin sandy and clayey varves; friable, slightly sticky, nonplastic; neutral.

These soils formed in stratified material that has various textures within a short vertical or horizontal distance. The upper 40 inches is dominantly moderately fine textured but typically has thin lenses or varves of medium- or coarse-textured material. In areas that are not limed, reaction ranges from medium acid in the A1 horizon to neutral in the C horizon. The solum ranges from 24 to 40 inches in thickness. Depth to bedrock is more than 10 feet.

The A horizon is commonly black to dark reddish brown in hue of 5YR or 7.5YR, but it ranges to very dark grayish brown in hue of 10YR. The O horizon is less than 15 inches thick and commonly is organic material. In many places there is an A horizon of mucky silt loam that is less than 20 percent organic matter and as much as 15 inches thick.

The B horizon is commonly gray (10YR 6/1) in hue of 7.5YR to 5Y. In most places there is a thin B1 horizon between the A horizon and the B2 horizon. In most places the B horizon contains more clay than the A horizon. The structure of the B horizon is generally weak, subangular blocky but in places ranges to moderate, subangular or angular blocky. In some places widely spaced vertically oriented streaks or cracks extend through the B horizon and into the C horizon.

The C horizon commonly ranges from dark brown to dark reddish brown in hue of 5YR or 7.5YR. Below a depth of 40 inches the C horizon has clayey or loamy texture with or without contrasting varves.

Biddeford soils are associated with Carlisle muck, Parsippany, Pompton, and Preakness soils and Muck, shallow over clay. They have a thinner layer of muck at the surface than Carlisle and Muck, shallow over clay. They have a layer of muck at the surface, whereas the Pompton, Preakness, and Parsippany soils do not.

Biddeford silt loam (Bd).—This soil is nearly level. Included in mapping are small areas of Muck, shallow over clay, and Parsippany soils. Also included are areas of the better drained Pompton and Minoa soils on many very small knobs, less than 2 acres in size.

This Biddeford soil has a high water table, is very frequently ponded, is susceptible to flooding, and has slow permeability. These characteristics limit its use for farming and community development.

Successful use of this soil depends on improved drainage, which is difficult to accomplish because of its low position, inadequate outlets, and the moderately fine textured subsoil. Where outlets are available, open ditches or a combination of open ditches and bedding systems are effective to improve drainage. This soil is generally used for woodland and wildlife. In many places it is used for dug ponds or impoundments. Capability unit VIw-46.

Boonton Series

The Boonton series consists of gently sloping to strongly sloping, well drained and moderately well drained soils. These soils are on hills within and at the margins of the basin formerly occupied by glacial Lake Passaic and on the rolling tops and side slopes of the traprock ridges. They have a strongly developed fragipan. The soils generally contain gravel throughout the profile and on some steeper slopes contain as much as 15 percent stones and cobbles in addition to gravel. They formed in stony glacial till that overlies fractured basalt or red shale and sandstone bedrock. The till is derived mostly from these rocks but is as much as 20 percent granitic gneiss.

In a representative profile the plow layer is dark-brown gravelly loam about 6 inches thick. The upper part of the subsoil is strong-brown heavy fine sandy loam about 24 inches thick. The lower part is a fragipan of mottled, dark-brown gravelly fine sandy loam 15 inches thick that is very firm and brittle when moist and hard and brittle when dry. The substratum, between depths of 45 and 60 inches, is brown gravelly sandy loam.

Permeability is slow in the fragipan. Available water capacity is moderate. After heavy rains and in winter and early in spring, perched water seeps laterally on top of the fragipan. In areas of these soils that contain gravel, cobbles, stones, and boulders, the coarse fragments reduce the available water capacity, and water stored below the fragipan is generally not available for use by plants.

Undisturbed areas of Boonton soils are used mostly for woodland of oak, hickory, ash, and yellow-poplar. Limited areas cleared for farming and are now in pasture or nurseries. Most areas are used for residential and industrial developments.

Representative profile of Boonton gravelly loam, 3 to 8 percent slopes, 250 yards east of Passaic Valley Road, 60 yards south of Foremost Mountain Road, in Montville Township:

Ap—0 to 6 inches, dark-brown (7.5YR 4/2) gravelly loam; weak, medium, granular structure; friable; common roots; 15 percent gravel and few cobbles, stones, and boulders, mostly angular or blocky pieces of basalt, red and brown shale, and granitic gneiss; strongly acid; clear, smooth boundary. 6 to 10 inches thick.

B2t—6 to 30 inches, strong-brown (7.5YR 5/6) heavy fine sandy loam; weak, fine, subangular blocky structure; friable; slightly sticky; common fine roots; 10 percent gravel and rare cobbles, stones, or boulders, mostly blocky basalt, red or brown shale or sandstone, and granitic gneiss; patchy, thick, glossy, reddish clay films on peds and in voids; strongly acid; abrupt, wavy boundary. 12 to 30 inches thick.

Bx—30 to 45 inches, dark-brown (7.5YR 4/4) gravelly fine sandy loam; few, fine, prominent, very dark gray (N 3/0) mottles; very weak, coarse, prismatic structure or massive that has widely spaced bleached vertical streaks; very firm and brittle; very few roots except along prism faces or vertical streaks; 20 percent angular gravel and cobbles and a few stones; very thick, patchy, reddish-brown clay films in voids or channels; strongly acid; clear, wavy boundary. 6 to 30 inches thick.

C—45 to 60 inches, yellowish-brown (10YR 5/4) gravelly sandy loam; massive; friable; 20 percent gravel and cobbles; slightly acid.

The solum ranges from 40 to 60 inches in thickness. Depth to bedrock is more than 6 feet. Depth to the fragipan ranges from 20 to 30 inches. Fine and very fine sand makes up a high proportion of the sand fraction throughout the soil. The content of gravel ranges from 5 to 20 percent; of cobbles, from 5 to 10 percent; and of stones, from a trace to 15 percent. Boulders are scattered on the surface and through the soil. Reaction is very strongly acid to strongly acid in the upper part of the profile and medium acid to neutral in the lower part.

The A horizon is 7.5YR or 10YR in hue, 3 or 4 in value, and 2 in chroma.

The B2t horizon is 7.5YR to 5YR in hue, 4 or 5 in value, and mainly 6, but ranging from 4 to 6, in chroma. In addition, in places very dark, nearly black stains are on ped surfaces or are associated with weathered pebbles; in other places low-chroma mottles are in the lower part of the Bt horizon just above the fragipan. The B2t and Bx horizons are heavy silt loam, fine sandy loam, loam, and their gravelly analogs. The fragipan has vertical ped surfaces or fracture zones that are bleached gray and have a horizontal polygonal pattern. The fragipan is firm to extremely firm.

The C horizon is variable in color, depending on the proportion of red and brown shale or traprock, but it ranges from 2.5YR where shale is abundant to 10YR where it is less common. This horizon has a value of 3 to 5 and a chroma of 4 to 6. It is generally free of low-chroma mottling but in places has pale-colored mottles.

Boonton soils are associated with the somewhat poorly drained Haledon soils, the well-drained Holyoke soils, and the well-drained gravelly Riverhead soils. Boonton soils are deeper than Holyoke soils. They lack the low-chroma matrix color that is common in Haledon soils and are less sandy than Riverhead soils.

Boonton gravelly loam, 3 to 8 percent slopes (BoB).—This soil has the profile described as representative of the series. Included in mapping are areas of bedrock outcrop, Holyoke soils, Boonton and Haledon extremely stony soils, and Haledon gravelly loam soils.

This soil has complex slopes and a moderate hazard of erosion. In addition, it is in small areas and is frequently associated with steep or rocky areas.

In its natural condition, the soil is suited to woodland and pasture. If stones are removed and erosion is controlled, the soil is suited to crops. Practices used to control erosion are mostly crop rotation and diversions. Drainage commonly is not a limitation for general farming, except where high-value crops are grown. Interceptor drains and stripcropping are beneficial in removing excess water and reducing erosion. Drought-resistant grasses and legumes, such as alfalfa, Ladino clover, orchardgrass, and bromegrass, are suited. The depth to rock and the presence of stones or boulders are limitations to deep excavation. Lateral seepage is likely in excavations. Capability unit IIe-5.

Boonton gravelly loam, 8 to 15 percent slopes (BoC).—This soils has a profile similar to the one described as

representative of the series, but it is commonly more eroded and has a slightly higher proportion of gravel, cobbles, and stones in the surface layer.

Included with this soil in mapping are small areas of short, 15- to 25-percent slopes of Haledon, Riverhead, and Rockaway soils. If farmed, these steeper soils need more intense practices to control erosion than this Boonton soil.

This soil is strongly sloping, and in many places the surface layer is 25 to 30 percent coarse fragments. In areas used for crops, stripcropping, diversions, and interceptor drains provide drainage and help to control erosion, runoff, and sediment. If areas where water seeps to the surface are used for building construction, erosion and unstable slopes are limitations. In such areas, diversions and interceptor drains at the top of the slopes and retaining walls are effective in providing the necessary protection. Capability unit IIIe-5.

Boonton and Haledon extremely stony soils, 8 to 15 percent slopes (BpC).—The areas of this mapping unit are dominated by either Boonton or Haledon extremely stony soils or consist of nearly equal parts of each. Areas dominated by Boonton soils are more common than those dominated by Haledon soils. These soils have a profile similar to the ones described as representative of their respective series, but the content of stones is about 5 to 10 percent, the surface layer of the Haledon soil is dominantly loam, and stones are spaced 3 to 5 feet apart on the surface.

Included with these soils in mapping are small areas of Holyoke soils.

The numerous stones make these soils generally unsuited to cultivation and limit their use largely to pasture, woodland, and wildlife habitat. The stones also limit community development. In addition, concentrated runoff and seepage water from surrounding higher areas can be a severe limitation to use of these soils for community development. Lateral seepage along the top of the fragipan commonly enters excavations, making the soil unstable at steep cuts for roads or homesites. Capability unit VIIs-22.

Califon Series

The Califon series consists of deep, nearly level to strongly sloping, moderately well drained and somewhat poorly drained soils. These soils are mostly in waterways or seepage areas at the base of slopes in the granitic gneiss uplands, but some are in the nearly level areas and depressions on the top of ridges, particularly Schooley's Mountain. They have a fragipan. The soils typically contain gravel and cobbles throughout. They formed in local colluvium or in deeply weathered till derived mainly from granitic gneiss, and they are underlain by material weathered from granitic gneiss.

In a representative profile the surface layer is very dark grayish-brown loam about 9 inches thick. The upper part of the subsoil is yellowish-brown clay loam about 14 inches thick, and the lower part is a fragipan of yellowish-brown, very firm sandy loam about 34 inches thick. It is distinctly mottled with yellowish, brownish, and grayish colors. The upper 19 inches of the substratum is part of the fragipan and is yellowish-brown, firm sandy loam. Below this, the substratum, to a depth of 100 inches, is yellowish-brown sandy loam that has bands of very pale brown and yellowish-red loamy sand and clay loam.

Permeability is moderate above and below the fragipan but slow in the fragipan. The available water capacity is moderate. Undisturbed areas of these soils are wet during winter and early in spring. In many places, where these soils are nearly level or in depressions, water remains ponded after heavy rains. The fragipan restricts the growth of roots and the penetration of water. Water stored below the fragipan is generally not available for use by plants. The soils are difficult to work with heavy equipment during wet periods and cold months. Water is perched at a depth of ½ foot to 4 feet for only a brief period late in winter and early in spring. Water is perched on top of the fragipan, and on slopes it moves laterally as seepage.

Nonstony areas of Califon soils are well suited to farming. Surface stones and cobbles have been removed from most cultivated fields and pasture. Wetness restricts the choice of crops and the timing of farming practices. The native vegetation is mostly upland oaks, ash, and yellow-poplar. Drained areas of these soils are well suited to improved pasture and to cultivated crops. Drainage diversions, interceptor drains, and spot drains help to improve drainage. Seasonally, a high perched water table and lateral seepage of water are the main limitations for community development.

Representative profile of Califon loam, 0 to 3 percent slopes, 300 yards southeast of Naughright Road, three-fourths of a mile north of Flocktown, 20 yards north of powerline south of hedgerow:

Ap—0 to 9 inches, very dark grayish-brown (10YR 4/2) loam, pale brown (10YR 6/3) dry; moderate, medium, crumb structure and weak, medium and coarse, subangular blocky; hard when dry, friable when moist, nonsticky and nonplastic when wet; 5 percent angular gravel and cobbles, dominantly granitic, but having traces of sandstone, chert, and quartzite; slightly acid; abrupt, smooth boundary. 6 to 10 inches thick.

B2t—9 to 23 inches, yellowish-brown (10YR 5/8) clay loam, strong brown (7.5YR 5/6) dry; weak, medium, angular blocky structure; hard when dry, friable when moist, sticky and slightly plastic when wet; 10 percent angular gravel and cobbles, mostly granitic material but having traces of sandstone, chert, and quartzite; dull discontinuous clay films on ped faces, on pebbles, and in pores and channels; medium acid; clear, wavy boundary. 12 to 24 inches thick.

Bx—23 to 38 inches, yellowish-brown (10YR 5/4) sandy loam, light yellowish brown (10YR 6/4) dry; common, coarse, distinct, reddish-yellow (7.5YR 6/8) mottles, common, coarse, distinct, light yellowish-brown (2.5YR 6/4) mottles, and few, fine, distinct, light brownish-gray (10YR 6/2) mottles; weak, very thick, platy structure; very hard when dry, very firm and brittle when moist, and slightly sticky and slightly plastic when wet; 10 percent coarse fragments, mostly granitic, but a small proportion of sandstone, chert, and quartzite; thick patchy clay films on peds and in pores and channels; medium acid; clear, wavy boundary. 12 to 36 inches thick.

Cx—38 to 57 inches, yellowish-brown (10YR 5/8) sandy loam; massive; firm and brittle; 10 percent coarse

fragments; strongly acid; gradual, wavy boundary. 0 to 20 inches thick.

IIC—57 to 100 inches, yellowish-brown (10YR 5/8) sandy loam that has bands of yellowish-red (5YR 5/8) and very pale brown (10YR 7/3) gritty loamy sand and clay loam; massive tending to part horizontally along bands; slightly firm; black (N 2/0) staining on some soft weathered gravel and cobbles and speckles in bands that are particularly pale in color; strongly acid.

The solum ranges from 36 to 60 inches in thickness. Depth to the fragipan is 20 to 30 inches, and depth to granitic gneiss bedrock is 6 feet or more. The A, B, and C horizons contain a few to 25 percent coarse fragments, dominantly angular gravel. The contact with bedrock in most places is obscured by a transition through residual saprolite. In some places the upper part of the profile is easily identified as old weathered till. In other places it is a surficial mantle of local alluvium or colluvium. Generally, it is difficult to distinguish between till, alluvium, and colluvium in the upper 3 feet. In areas that are not limed, reaction is medium acid in the surface layer and strongly acid in the C horizon.

The A horizon is 10YR in hue, 3 or 4 in value, and 2 or 3 in chroma.

The Bt horizon is 7.5YR to 10YR in hue, 5 to 6 in value, and 4 to 8 in chroma. The horizon is dominantly clay loam, but ranges to sandy clay loam. It is friable to firm. The fragipan is sandy loam or loam. Low-chroma mottles are at a depth of 18 to 30 inches but not within the upper 10 inches of the Bt horizon. The fragipan is firm to extremely firm sandy loam or loam. In many places the fragipan does not extend into the C horizon.

The IIC horizon commonly contains bands that are 5YR to 2.5Y in hue, and they have a wide range in value and chroma, depending on the degree of weathering and the kinds of minerals present.

Califon soils are associated with Annandale, Edneyville, Cokesbury, and Turbotville soils. All except the Turbotville soils formed in similar material. Califon soils differ from Annandale and Edneyville soils in having mottles. They lack the low-chroma matrix color that is common in Cokesbury soils. They lack the low-chroma mottles in the upper part of the B horizon that are common in Turbotville soils.

Califon loam, 0 to 3 percent slopes (CaA).—This soil has the profile described as representative of the series. Included in mapping are small areas of poorly drained Cokesbury soils, well-drained Annandale soils, and the Califon friable subsoil variant. Also included are small areas of Califon gravelly loam or very stony loam.

In its natural condition, this soil is suited to pasture, hay, woodland, and general crops. If high-value crops are grown, drainage is needed. The dominant properties that affect the use of this nearly level soil are slow runoff, its position on the landscape where it receives runoff from surrounding higher areas, restricted root growth and slow permeability in the fragipan, and perched ground water on top of the fragipan. Drainage diversions, subsurface interceptor drains, and spot drains have been used to improve this soil for intensive farming and for community development. Capability unit IIw-71.

Califon loam, 3 to 8 percent slopes (CaB).—This soil is in small narrow waterways or elongated areas at the base of steeper slopes adjacent to large areas of well-drained soils.

Included with this soil in mapping are small areas of well-drained Annandale and Edneyville soils and the Califon friable subsoil variant. Also included are areas of Califon gravelly loam and very stony loam.

Because this soil is gently sloping, the hazard of erosion is moderate. Diversions, subsurface interceptor drains, and spot drains help to improve drainage. In addition, crop rotation, stripcropping, and diversions help to control erosion. Drainage is a limitation for community development. Lateral seepage of water and a perched water table limit septic fields and building foundations. Early establishment of good cover on lawns and play areas provides adequate protection against erosion. Capability unit IIe-71.

Califon loam, 8 to 15 percent slopes (CaC).—This soil is in small narrow waterways or elongated narrow seepage areas on the lower parts of steeper slopes.

Included with this soil in mapping are small areas of Califon gravelly loam and very stony loam. Also included are areas of well-drained Annandale and Edneyville soils.

Runoff is rapid, and the hazard of erosion is severe.

In its natural condition, this soil is used for woodland. It is suited to general crops, hay, and pasture. If this soil is used for intensive farming, erosion control practices are required. If high-value crops are grown, drainage is needed in places. For community development, this strongly sloping soil is limited by lateral seepage and the moderately severe hazard of erosion. Lateral movement of water in excavations makes stabilization of such areas particularly difficult. In many places it is necessary to install interceptor drains above steep banks to prevent an unstable condition. Capability unit IIIe-71.

Califon gravelly loam, 3 to 8 percent slopes (CbB).—This soil is generally in wide waterways. It has a profile similar to the one described as representative of the series, but it is 20 percent or more gravel throughout.

Included with this soil in mapping are areas of more strongly sloping soils and some small areas of soils that are cobbly, stony, and bouldery. Also included are areas of Califon loam, the Califon friable subsoil variant, poorly drained Cokesbury soils, and well-drained Annandale and Edneyville soils.

Runoff is slow on the nearly level included soils in depressions, and the soils often remain ponded for a brief period after heavy rains. Runoff is more rapid on the strongly sloping included soils, and erosion is a hazard.

If this soil is used for cultivated crops, drainage, removal of stones, and control of erosion on steeper slopes are needed. If this soil is used for community development, poor drainage, the lack of adequate outlets in some depressions, the content of gravel and stones, and the hazard of erosion on steeper soils are limitations. This soil is used as sites for ponds. Capability unit IIe-71.

Califon very stony loam, 2 to 8 percent slopes (CcB).—This soil is mainly in broad nearly level waterways or on gently sloping lower slopes. It has a profile similar to the one described as representative of the series, but it has more stones, cobbles, and gravel throughout, and stones are spaced 5 to 30 feet apart.

Included with this soil in mapping are areas of Califon gravelly loam, Califon loam, and the Califon friable subsoil variant. Also included in places are small

areas of well-drained Annandale and Edneyville soils and poorly drained Cokesbury soils.

This soil is limited by its content of stones, cobbles, and gravel; isolated bouldery areas; water seepage along the top of the fragipan; slow permeability in the fragipan; and slow or medium runoff. Unless the stones are removed, this soil is better suited to pasture or to woodland than to other uses. Stone removal is essential in areas used for crops. Also needed are drains to intercept the seepage and runoff from surrounding higher areas, and surface drainage to get rid of the surface water. If this soil is used for community development, excess water and the presence of stones and some boulders are limitations. On small lots in many places drainage outlets are difficult to find. These soils are natural sites for ponds. Capability unit VIs-75.

Califon very stony loam, 8 to 15 percent slopes (CcC).—This soil is in long, narrow, strongly sloping waterways. It has a profile similar to the one described as representative of the series, but it is very stony and has 20 to 30 percent gravel and cobbles throughout. Stones cover as much as 3 percent of the surface and are generally spaced 5 to 30 feet apart.

Included with this soil in mapping are areas of less stony Califon soils and the Califon friable subsoil variant. Also included are small areas of well-drained Annandale gravelly loam and Edneyville gravelly loam.

The properties that affect the use of this soil are the content of stones, cobbles, and gravel; lateral seepage; slow permeability in the fragipan; and a moderately severe hazard of erosion.

This soil is used almost exclusively for woodland. The content of stones is the main property that affects its suitability for cultivation. The soil is suitable for hay and pasture. The need for drainage, the content of stones and other coarse fragments, and the hazard of erosion are limitations for community development. Capability unit VIs-75.

Califon Variant

The Califon variant, consists of deep, gently sloping, somewhat poorly drained and moderately well drained soils. These soils are in waterways or swales on uplands and in many places at the base of steeper slopes. The areas along waterways are elongated and branched, and those at the base of steeper slopes are small and isolated. Coarse fragments are mostly angular granitic gneiss gravel and a few cobbles and stones. These soils formed in a combination of till, local colluvium, and material weathered from granitic gneiss. The underlying granitic gneiss bedrock is fractured and weathered to a depth of many feet.

In a representative profile about 4 inches of partly decomposed leaves and twigs overlies 2 inches of black humus. The mineral surface layer is very dark brown loam about 3 inches thick. The upper part of the subsoil is dark-brown gravelly loam about 9 inches thick, the middle is brown gravelly sandy clay loam and sandy clay loam about 20 inches thick, and the lower part is brown sandy loam about 8 inches thick. Below a depth of 12 inches, the subsoil has yellowish, brownish, and grayish mottles. The substratum, between depths of 40 and 60 inches, is brown weathered granitic gneiss or weathered till of sandy loam texture that contains narrow bands of strong-brown and reddish-brown material.

Permeability and available water capacity are moderate. Undisturbed areas of these soils are wet during winter and early in spring. In warm seasons, they remain ponded for several days after heavy rains. During winter and early in spring, the water table rises to within ½ foot to 4 feet of the surface, but in summer it gradually recedes to a greater depth.

Most areas of these soils have been cleared for farming.

Representative profile of Califon loam, friable subsoil variant, 3 to 8 percent slopes, in the edge of the woods, 50 yards west of Ironia Road, 300 yards north of telephone cable crossing, in Mendham Township:

O1—4 inches to 1 inch, leaves and sticks from last couple of years, mostly oak and maple, but some elm; abrupt, wavy boundary. 3 to 6 inches thick.

O2—1 inch to 0, black (10YR 2/1) humus of decomposed leaves and twigs; gradual, wavy boundary. ½ inch to 2 inches thick.

A1—0 to 3 inches, very dark brown (10YR 3/2) loam; moderate, coarse, crumb structure; friable; mat of fine fibrous roots; very porous, 10 percent angular granitic gneiss pebbles, less than 1 percent angular stones, boulders, and cobbles; strongly acid; clear, wavy boundary. 1 to 3 inches thick.

B1—3 to 12 inches, dark-brown (10YR 4/3) gravelly loam; moderate, coarse, crumb structure and moderate, medium, subangular blocky; friable; many fine fibrous roots and some large conductor roots; many pores; 15 percent angular granitic gneiss gravel, less than 1 percent cobbles, stones, and boulders; humus-colored coatings in channels and voids and on some peds; very strongly acid; diffuse, wavy boundary. 4 to 10 inches thick.

B21t—12 to 20 inches, brown (7.5YR 4/4) gravelly sandy clay loam; few, fine, distinct, yellow (10YR 7/6) and light brownish-gray (10YR 6/2) mottles in the upper part and many coarse mottles in the lower part; moderate, medium, subangular blocky structure; friable; many fine fibrous roots in the upper part, some in the lower part; 15 percent angular granitic gneiss gravel, less than 5 percent cobbles, stones, and boulders; discontinuous clay films on most ped surfaces, in voids, and on pebbles; very strongly acid; diffuse, wavy boundary. 16 to 28 inches thick.

B22t—20 to 32 inches, brown (7.5YR 4/4) sandy clay loam; many, coarse, distinct, strong-brown (7.5YR 5/8) and light brownish-gray (10YR 6/2) mottles; moderate, medium, subangular blocky structure; friable; few roots, decreasing in number and size with increasing depth; 10 percent angular granitic gneiss pebbles, cobbles, and stones; clay films on sand grains, gravel, and ped faces; very strongly acid; clear, wavy boundary. 0 to 12 inches thick.

B3—32 to 40 inches, brown (7.5YR 4/4) sandy loam; common, coarse, faint, strong-brown (7.5YR 5/8) mottles; massive; friable; few roots; clay bridging between sand grains; very strongly acid; gradual, wavy boundary. 0 to 10 inches thick.

C—40 to 60 inches, brown (7.5YR 4/4) sandy loam saprolite or weathered till that has narrow bands of strong brown (7.5YR 5/6) and reddish brown (5YR 5/4); massive; firm to friable; color bands related to mineralogy; very strongly acid.

The solum ranges from 30 to 58 inches in thickness. Depth to bedrock is 10 feet or more. These soils contain various amounts of angular granitic gneiss coarse fragments. The solum contains 10 to 20 percent gravel, 0 to 5 percent cob-

bles, and 0 to 1 percent stones. Reaction ranges from very strongly acid to medium acid throughout.

The A horizon has a hue of 10YR, value of 2 to 4, and chroma of 1 to 3. In most places it is loam, but gravelly loam also occurs.

The B horizon has a hue of 7.5YR or 10YR, value of 4 or 5, and chroma of 3 to 8. Mottles range from few, fine, faint to many, coarse, distinct. In most places they increase in number in the lower part of the B horizon. This horizon is loam, sandy clay loam, heavy sandy loam, and their gravelly analogs.

The C horizon does not have color banding in all places. This horizon is generally less than 5 percent coarse fragments, but where the rock was coarse quartz it is 10 to 15 percent coarse fragments. The contact with bedrock is typically diffuse and irregular, but in some places it is abrupt and wavy.

The Califon variant is associated with Edneyville, Parker, Califon, and Cokesbury soils. The Califon friable subsoil variant has mottles, which Edneyville and Parker soils lack. It lacks the fragipan that is common in Califon soils. It does not have the low-chroma matrix that is common in Cokesbury soils.

Califon loam, friable subsoil variant, 3 to 8 percent slopes (CdB).—Included with this soil in mapping are areas of soils that have slightly more gravel in the surface layer, which is gravelly loam. These areas make up about 25 percent of the mapping areas. Also included are small areas of Edneyville and Cokesbury soils.

This soil is suited to pasture, cultivated crops, and woodland. If adequately drained, it is suited to the general crops grown in the county. Open ditches and underdrains help to lower the water table. Such conservation practices as crop rotation, cover crops, and contour cultivation help to reduce erosion. A moderately high seasonal water table and ponding after rains are the main limitations to community development. Capability unit IIe-71.

Carlisle Series

The Carlisle series consists of deep, nearly level, very poorly drained organic soils. These soils are in depressions that were formerly or are now partly occupied by lakes or ponds. Over a period of thousands of years, these lakes or ponds have gradually been filling by the accumulation of organic material or a mixture of mineral sediment and organic material. Budd Lake, Lake Denmark, and Green Pond are examples of lake basins that are now partly filled with organic soils. Black Meadow and Great Swamp are examples of former lake basins that are now filled with organic soils.

In a representative profile the surface layer is black, highly decomposed muck about 18 inches thick. Below this, and extending to a depth of 60 inches, is very dark grayish-brown, decomposed muck that contains many fibers and pieces of wood.

Permeability is rapid, and available water capacity is high. The water table is at or above the surface most of the time. These soils are compressible and unstable under load and subside if they are drained.

Drained areas of Carlisle soils are suited to cultivated crops, especially vegetables. They are also suitable for sod production. The native vegetation is either marsh sedges and reeds or wetland trees. Red maple, ash, elm, and tamarack are common trees.

Representative profile of Carlisle muck, in a cutover area, about 2 miles northeast of Meyersville, along a powerline at the south edge of Great Swamp National Wildlife Refuge:

Oa1—0 to 18 inches, black (10YR 2/1, broken face and rubbed) muck (sapric material); about 30 percent fiber, less than 10 percent rubbed; moderate, coarse, granular structure parting to fine, granular; common woody fragments as much as 3 inches in diameter; medium acid; gradual, smooth boundary.

Oa2—18 to 60 inches, very dark grayish-brown (10YR 3/2, broken face and rubbed) muck (sapric material); about 50 percent fibers, less than 10 percent rubbed; massive; slightly sticky; many woody fragments, as much as 6 inches in diameter, in a fibrous matrix; medium acid.

The organic deposit ranges from 51 inches to more than 10 feet in thickness but is typically less than 6 feet. Depth to bedrock is 10 feet or more. Woody fragments are throughout the profile in most places. They consist of branches or logs and make up 2 to 25 percent of the material, by volume. Fragments range from ¼ inch to 10 inches in diameter.

The surface tier is black (5YR 2/1, 10YR 2/1, or N 2/0). It is mainly sapric material or various proportions of hemic and sapric material. The subsurface tier ranges from very dark grayish brown (10YR 3/2) to dark reddish brown (5YR 2/2). Broken faces become darker upon exposure to air. This tier is dominantly sapric material, but in many places it contains thin layers of hemic material. It is typically massive but in places has blocky or granular structure. Reaction of this tier is medium acid or slightly acid. The bottom tier is similar to the subsurface tier, but herbaceous fibers are generally dominant.

Carlisle muck (Cm).—This soil is in low swampy areas. Included in mapping are large areas of similar and contrasting soils in a complex pattern. The main included soils are deep organic soils that are fibrous and less decomposed than this soil below a depth of 12 inches. North of Lincoln Park, in Bog and Valley Meadows, are large included areas of organic soils that are dominantly spongy, brownish sedimentary peat below a depth of 12 inches. In Budd Lake Bog there are small included areas of floating organic soils and of organic soils that are high in content of peat consisting of the remains of sphagnum moss. Most areas of this Carlisle muck, particularly those around the edges of areas that grade toward mineral soils, have included areas of organic soils that are less than 51 inches deep over a mineral substratum.

This soil needs drainage if it is farmed. Some attempts have been made to drain Bog and Valley Meadows and Black Meadows. These areas have been used to a limited extent for vegetables. The drainage systems, however, are inadequate, because suitable outlets are not available. The northern part of Bog and Valley Meadows is drained by tile lines that empty into swamps. The water is pumped from the swamps into shallow surface ditches. Cut flowers, potted plants, and other specialty crops are raised on a small scale.

Because the water table is high and the soil is unstable, Carlisle muck is poorly suited to community development. If adequately drained, this soil is suitable for very intensive farming and for specialized nursery crops; however, subsidence is severe. Capability unit IIIw-41.

Cokesbury Series

The Cokesbury series consists of deep, nearly level to gently sloping, poorly drained soils. These soils are in waterways, depressions, and elongated areas that extend along the bases of steeper slopes in the granitic highlands of the southwestern part of the county. They have a moderately developed fragipan. The soils are generally cobbly and stony, but in places the surface is almost free of stones. They formed in weathered glacial till and colluvium derived mainly from granitic gneiss, and they are underlain by weathered granitic gneiss.

In a representative profile the plow layer is very dark grayish-brown gravelly loam about 9 inches thick. The upper part of the subsoil is 6 inches of light-gray loam mottled with light olive brown and strong brown, and the middle is about 10 inches of light brownish-gray gravelly clay loam mottled with light yellowish brown and strong brown. The lower part is a fragipan of strong-brown, extremely firm loam about 10 inches thick that is mottled with light gray and light yellowish brown. The substratum, between depths of about 35 and 60 inches, is pale-brown gravelly loam mottled with strong brown, light gray, and dark reddish brown. Although Cokesbury soils are loamy throughout, they have enough sand to cause them to feel distinctly gritty in the subsoil.

Permeability is slow in the fragipan, and available water capacity is moderate. Runoff is slow in depressions of nearly level areas. Locally, the water table is perched at or near the surface for long periods during winter and spring and after heavy rains. In addition, areas of these soils receive much runoff and seepage water from surrounding soils that occupy higher positions. These soils contain cobbles, stones, and boulders.

Undisturbed areas of Cokesbury soils are used mostly for woodland. If the soils are used for crops or pasture, drainage improvement, stone removal, and control of erosion on gentle slopes are needed. Where these soils are in low positions, they are natural sites for waterways and ponds.

Representative profile of Cokesbury gravelly loam, 0 to 3 percent slopes, 200 feet northeast of junction of Hanover Avenue and Raynor Road, in Parsippany-Troy Hills Township:

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) gravelly loam; weak, fine, subangular blocky and weak, medium, granular structure; friable; many roots; 20 percent angular gravel, a few cobbles, mostly granitic gneiss and some sandstone; slightly acid; abrupt, smooth boundary. 7 to 10 inches thick.

B1g—9 to 15 inches, light-gray (2.5Y 7/2) heavy loam; many, coarse, distinct, prominent, light olive-brown (2.5Y 5/4) and strong-brown (7.5YR 5/8) mottles; weak, coarse, prismatic structure; friable; many roots; 10 percent angular gravel and cobbles; slightly acid; gradual, wavy boundary. 4 to 10 inches thick.

B2tg—15 to 25 inches, light brownish-gray (2.5Y 6/2) gravelly clay loam; interiors of peds have common, coarse, distinct, light yellowish-brown (10YR 6/4) and strong-brown (7.5YR 5/8) mottles; moderate, very coarse, prismatic structure parting to moderate, medium, subangular blocky; friable, slightly plastic; many roots; 15 percent gravel and cobbles; isolated, discontinuous, glossy clay coatings on ped faces; medium acid; clear, wavy boundary. 9 to 14 inches thick.

Bx—25 to 35 inches, strong-brown (7.5YR 5/8) heavy loam; many, coarse, distinct, light yellowish-brown (10YR 6/4) mottles and common, coarse, prominent, light-gray (2.5Y 7/2) mottles; weak, very coarse, prismatic structure parting to weak, very thick, platy; extremely firm; few roots distributed along faces of peds; 10 percent angular gravel and cobbles; patchy clay films in voids and on ped faces; few, brown, (7.5YR 5/4) soft nodules one-fourth inch in diameter; strongly acid; distinct, wavy boundary. 6 to 10 inches thick.

C—35 to 60 inches, pale-brown (10YR 6/3) gravelly loam; common, coarse, prominent, strong-brown (7.5YR 5/8) and light-gray (2.5Y 7/2) mottles and few, medium, distinct, dark reddish-brown (2.5YR 2/4) mottles; weak, very thick, platy and weak, very coarse, prismatic structure; extremely firm; about 30 percent angular gravel, cobbles, and stones; strongly acid.

The solum ranges from 26 to 40 inches in thickness. Depth to the fragipan is 20 to 30 inches, and expression of the pan ranges from weak to strong but is generally moderate. Depth to bedrock is 6 feet or more. Coarse fragments make up 5 to 25 percent of the solum and 30 to 50 percent of the C horizon. Stones range from few to many. Coarse fragments are mainly granitic gneiss, and in most places less than 20 percent of the coarse fragments and the fine-earth material were derived from shale, sandstone, or siltstone. In areas that are not limed, reaction ranges from strongly acid to medium acid.

The A1 and Ap horizons are very dark grayish brown (2.5Y 3/2) to dark gray (10YR 4/1). The A horizon is gravelly loam or extremely stony loam.

The upper part of the B horizon is dark grayish brown (10YR 4/2) to light gray (5Y 7/1) and has few to many, medium to coarse, strong-brown (7.5YR 5/8) to light olive yellowish-brown (2.5Y 6/4), high-chroma mottles and faint low-chrome mottles. Low chromas dominate ped faces and matrix colors in the upper part of the B horizon and are present as mottles in the lower part of the B horizon. The B horizon is heavy loam, sandy clay loam, clay loam, silty clay loam, and their gravelly analogs. The Bt and Bx horizons have prismatic, platy, or subangular blocky structure. Consistence ranges from friable above the fragipan to firm or extremely firm in the fragipan.

The C horizon ranges from brown (7.5YR 5/4) to pale brown (10YR 6/3) to brownish yellow (10YR 6/6). Low-chroma mottles range from dark grayish brown (10YR 4/2) to light gray (5Y 7/2). This horizon is loam or sandy loam.

Cokesbury soils are associated with the well-drained Annandale and Edneyville soils and the moderately well drained and somewhat poorly drained Califon soils. They are wetter than Annandale, Edneyville, and Califon soils, and they lack the brown colors in the upper part of the B horizon that is characteristic of those soils.

Cokesbury gravelly loam, 0 to 3 percent slopes (CoA).—This soil has the profile described as representative of the series. Included in mapping are some areas of extremely stony Cokesbury and Califon soils. Where this soil is adjacent to Washington or Bartley soils, it is likely that fractured limestone bedrock rather than granitic gneiss bedrock is at a depth of more than 10 feet.

Properties that affect use of these soils are poor drainage, coarse fragments, and content of stones. In its natural condition, this soil is used for woodland. If adequately drained, it is suited to cultivated crops. Surface drainage and interceptor drains help to improve drainage. Removal of stones is needed in some small isolated areas. For community development, this soil has limitations caused by periods of saturation and

the presence of coarse fragments. Because of its low position in the landscape and the presence of a high perched water table, this soil is well suited to ponds (fig. 8). Capability unit IVw-82.

Cokesbury gravelly loam, 3 to 8 percent slopes (CoB).—This soil has a profile similar to the one described as representative of the series, but the plow layer is lighter colored. In cultivated areas the soil is commonly eroded.

Included with this soil in mapping are areas of extremely stony Cokesbury soils and Califon soils and some small areas of soils that are more strongly sloping than this soil. Where this soil is adjacent to Washington or Bartley soils, it is likely that limestone bedrock rather than granitic gneiss bedrock is at a depth of more than 10 feet.

Use of this soil is limited by poor drainage, coarse fragments, and the hazard of erosion. Suitable erosion control practices include constructing diversions and establishing grassed waterways. Drainage is needed if this soil is used for crops. This soil is well suited to ponds. Capability unit IVw-82.

Cokesbury extremely stony loam, 0 to 8 percent slopes (CsB).—This soil has a profile similar to the one described as representative of the series, but it has an extremely stony surface that in places is bouldery. Stones cover 5 to 15 percent of the surface and are spaced 2 to 5 feet apart.

Included with this soil in mapping are small areas of soils that are less stony or gravelly than this soil and some very wet spots. Making up 10 percent of the mapped areas are soils that are similar to this Cokesbury soil, but they do not have a fragipan in the subsoil.

Soil properties that affect the use of this soil include stoniness, poor drainage, slow permeability, and the low position on the landscape. The high content of stones makes this soil unsuitable for crops and pasture. Capability unit VIIs-77.

Edneyville Series

The Edneyville series consists of deep, gently sloping to steep, well-drained loamy soils. These soils generally contain granitic gneiss gravel, cobbles, and stones. They occur in irregularly shaped areas, generally 10 to 40 acres in size, on the gently rolling tops of ridges and the somewhat more stony side slopes.

In a representative profile the surface layer is very

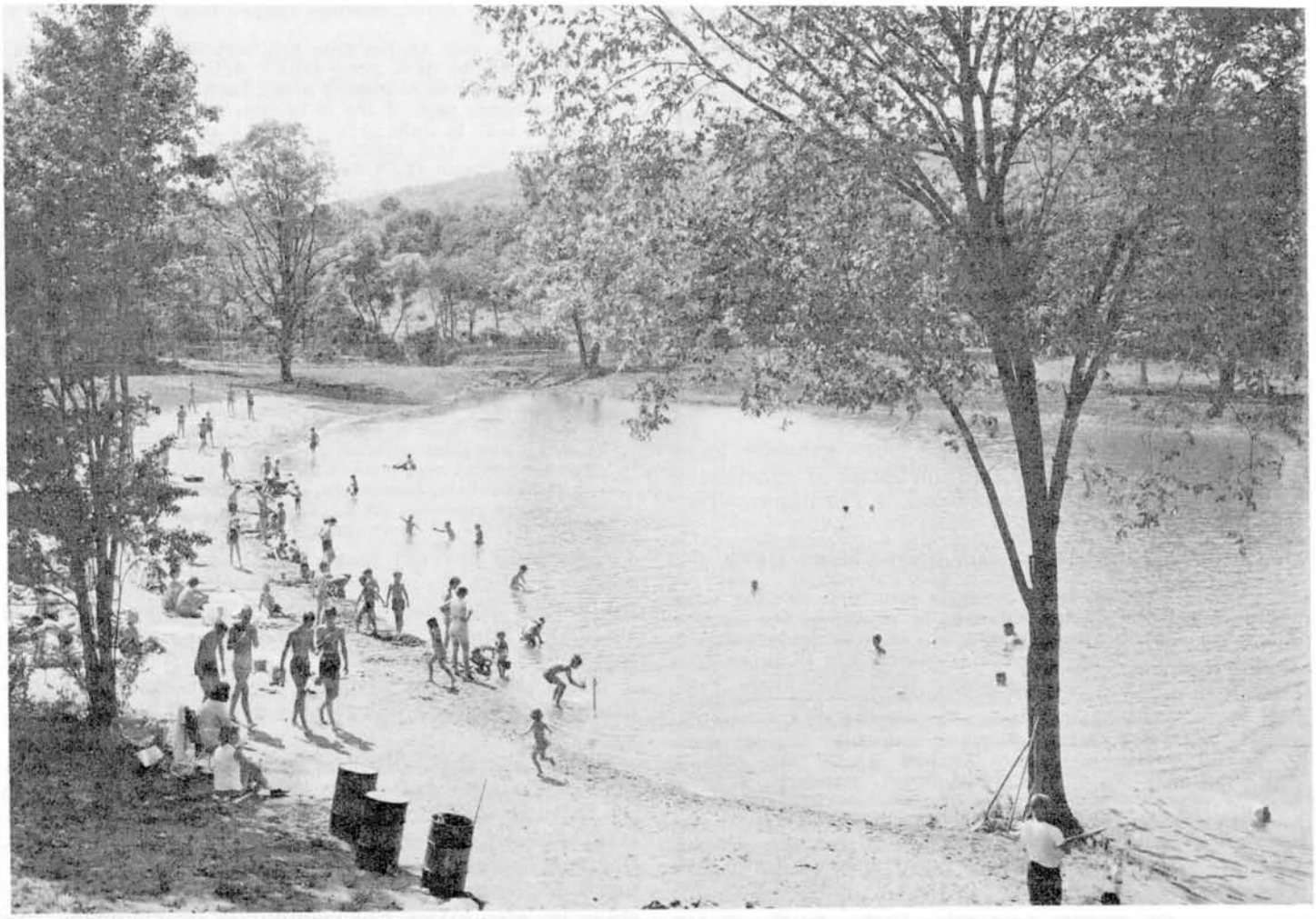


Figure 8.—**Mendham recreation pond on an area of Cokesbury soils.**

dark grayish-brown gravelly loam about 10 inches thick. The upper part of the subsoil is brown sandy clay loam about 12 inches thick, and the lower part is strong-brown heavy sandy loam about 15 inches thick. The substratum, between depths of 37 and 96 inches, is strong-brown sandy loam that contains bands of sandy clay loam.

Permeability and available water capacity are moderate. The sand and gravel fractions are well graded, and the soil contains enough clay to give good compaction characteristics. Roots penetrate throughout the profile.

Gently sloping and strongly sloping Edneyville soils are well suited to farming and to community development. Steep Edneyville soils have limitations for both farming and community development.

Representative profile of Edneyville gravelly loam, 3 to 8 percent slopes, in a cultivated field, 20 feet west of the northeast corner of the parking lot across Hanover Avenue from the office of the Morris County Planning Board:

Ap—0 to 10 inches, very dark grayish-brown (10YR 3/2) gravelly loam; moderate, fine and medium, subangular blocky structure and moderate, medium, crumb; friable; many fine fibrous roots; 15 percent strongly weathered subangular granitic gneiss gravel; medium acid; abrupt, smooth boundary. 6 to 10 inches thick.

B2t—10 to 22 inches, brown (7.5YR 5/4) sandy clay loam; moderate, medium and coarse, subangular blocky structure; friable; common roots; nearly continuous, slightly glossy, dark-brown (7.5YR 4/4) clay films on peds, prominent patches of clay films on isolated horizontal surfaces and pebbles; 10 percent slightly weathered gravel, 2 to 4 percent cobbles; slightly acid; clear, wavy boundary. 10 to 20 inches thick.

B3—22 to 37 inches, strong-brown (7.5YR 5/6) heavy sandy loam; very weak, thick, platy structure; slightly firm in place, slightly brittle; common roots; pores and voids generally filled with silt, very fine sand, and clay; medium acid; gradual, wavy boundary. 5 to 20 inches thick.

C—37 to 96 inches, strong-brown (7.5YR 5/6) sandy loam that has bands of sandy clay loam; massive; slightly firm; few, fine, fibrous roots; many clean sand grains and clean gravel, some pebbles slightly weathered; strongly acid.

The solum ranges from 30 to 40 inches in thickness. Depth to granitic gneiss bedrock ranges from 6 to more than 10 feet. In places the bedrock is weathered for several feet. The solum ranges from 5 to 35 percent coarse fragments, which consist of 5 to 25 percent gravel, 0 to 5 percent cobbles, and 0 to 15 percent stones. In areas that are not limed, reaction ranges from strongly acid to very strongly acid throughout.

Unplowed areas of Edneyville soils have a dark-colored A1 horizon 1 inch to 3 inches thick. The A horizon ranges from dark brown (10YR 4/3) to (7.5YR 3/2). This horizon is gravelly loam or sandy loam or is extremely stony in places.

The Bt horizon ranges from brown (7.5YR 4/4) to yellowish brown (10YR 5/6). This horizon ranges from heavy sandy loam to clay loam and their gravelly analogs.

The C horizon is 2.5Y to 5YR in hue, 4 to 7 in value, and 4 to 8 in chroma. This horizon is sandy loam and in some places is loamy sand below a depth of 40 inches. This horizon ranges from 0 to 35 percent coarse fragments. Thin bands of finer textured, redder material are typical but are lacking in many places.

Edneyville soils are associated with Parker, Annandale, and Califon variant soils. Edneyville and Parker soils and the Califon variant formed in similar material. Edneyville soils contain more clay and less coarse fragments than Parker soils. They lack the gray mottling that is common in the Califon variant. Edneyville soils lack the fragipan that is common in Annandale soils.

Edneyville gravelly loam, 3 to 8 percent slopes (EdB).—This soil has the profile described as representative of the series. Included in mapping are some areas of Parker soils and other Edneyville soils.

This soil is well suited to corn, small grains, hay, pasture, and most special or vegetable crops grown in the county. It has a slight hazard of erosion, which generally is easily controlled by such cropping practices as crop rotation, contour cultivation, and cover crops. High-value crops are generally irrigated. Capability unit IIe-58.

Edneyville gravelly loam, 8 to 15 percent slopes (EdC).—This soil is on side slopes in rolling to hilly areas used largely for pasture and hay. Included in mapping are some small areas of eroded Edneyville soils and stony loams and stony sandy loams of the Edneyville and Parker series.

This soil is suited to small grain, corn, hay, pasture, and most specialized and vegetable crops grown in the county. The hazard of erosion is moderately severe. Diversions, crop rotation, contour cultivation, and stripcropping help to control erosion. Slope is a limitation of this soil for some community development uses. Capability unit IIIe-58.

Edneyville gravelly loam, 15 to 25 percent slopes (EdD).—This soil has a profile similar to the one described as representative of the series, but the content of coarse fragments is about 20 percent. Included in mapping are small areas of less steep Edneyville gravelly loam and Parker extremely stony sandy loam soils.

Steepness and the severe hazard of erosion severely limit the suitability of this soil for crops. If farmed, this soil needs careful management, including crop rotation and contour strips to control erosion. It is not suited to continuous cultivation of row crops. Steepness is a severe limitation for many community developments. Capability unit IVe-58.

Ellington Variant

The Ellington variant, consists of gently sloping to steep, moderately well drained and somewhat poorly drained soils. These soils are on the sides of the Watchung ridges within basins formerly occupied by glacial Lake Passaic. They formed in somewhat gravelly material that was derived from shale, siltstone, and sandstone but contains a small amount of other materials, including granitic gneiss. They are underlain at a depth of 36 to 72 inches by finer textured residual material weathered from trap or shale bedrock.

In a representative profile the plow layer is dark-brown fine sandy loam about 10 inches thick. The subsoil is brown fine sandy loam about 10 inches thick that contains a few, fine, faint, grayish-brown and brown mottles. The substratum, between depths of 20 and 40 inches, is yellowish-brown very fine sandy loam that is mottled with strong brown, and between depths of 40 and 60 inches is yellowish-red, slightly firm gravelly clay loam that is plastic when wet.

Permeability is moderately slow, and available water capacity is moderate. The high content of fine sand limits the stability and workability of the soils, especially during winter, early in spring, and after heavy rains. The soils are likely to have a perched water table and seepage on top of the more slowly permeable substratum. They receive seepage and runoff from adjacent soils that occupy higher positions. Roots can penetrate throughout the profile.

The native vegetation of the Ellington variants is mostly oak and hickory trees, but in the wetter areas elm or maples are dominant. In cultivated areas these soils are used extensively for hay, pasture, and nurseries. The soils are in intermediate positions on long slopes. In steep cultivated areas, they are particularly susceptible to erosion.

Representative profile of Ellington fine sandy loam, loamy subsoil variant, 3 to 8 percent slopes, near the middle of a cultivated field, one-fourth mile north of Lee's Hill Road, 100 yards east of Young's Road:

Ap—0 to 10 inches, dark-brown (7.5YR 4/2) fine sandy loam; moderate, medium, granular structure; very friable; common roots; 5 percent angular gravel, mostly blocky fragments of traprock and some granitic gneiss; medium acid; abrupt, smooth boundary. 6 to 10 inches thick.

Bt—10 to 20 inches, brown (7.5YR 4/4) fine sandy loam; few, fine, faint, grayish-brown (10YR 5/2) and brown (10YR 5/3) mottles; weak, fine, subangular blocky structure; very friable; common roots; very slightly more clay than horizon above; 10 percent gravel, mostly traprock and shale but some granitic gneiss; strongly acid; gradual, wavy boundary. 10 to 24 inches thick.

C1—20 to 40 inches, yellowish-brown (10YR 5/4) very fine sandy loam; few, fine, faint, strong-brown (7.5YR 5/8) mottles; weak, fine, subangular blocky structure or massive; very friable; common roots; 10 percent gravel, mostly traprock and shale fragments but some granitic gneiss; strongly acid; clear, wavy boundary. 6 to 30 inches thick.

IIC2—40 to 60 inches, yellowish-red (5YR 5/6) gravelly clay loam; massive; slightly firm and plastic; few roots; 20 percent coarse fraction of 15 percent gravel and 5 percent cobbles or stones of traprock; strongly acid.

The solum ranges from 20 to 30 inches in thickness. Depth to bedrock in most places is more than 10 feet. Coarse fragments make up 5 to 20 percent throughout. Gravel-size fragments are most abundant. The IIC horizon is as much as 10 percent cobbles, stones, and boulders. In areas that are not limed, reaction is strongly acid or very strongly acid throughout.

The matrix of the A horizon is commonly 7.5YR in hue.

The matrix of the B horizon is 7.5YR or 5YR in hue, 4 or 5 in value, and 4 to 6 in chroma. Mottles range from few, fine, faint to many, coarse, prominent in hue of 5YR or 10YR, value of 3 to 8, and chroma of 1 to 8. In some places medium or coarse, prominent mottles occur throughout the B horizon.

The color, texture, and mineralogy of the C horizon are variable, depending largely on the composition of the parent material. The parent material includes deep stratified deposits, weathered shale, and weathered traprock. This horizon is 2.5YR to 10YR in hue. It ranges from gravelly sandy loam to silty clay loam. On the lower part of slopes weathered shale is at a depth of 3 to 6 feet.

The Ellington variants are associated with the well-drained gravelly and sandy Riverhead soils, the stony and more clayey Neshaminy soils, and the somewhat poorly drained gravelly and sandy Pompton soils. They contain less gravel and sand than Riverhead soils and less sand than Pompton soils. They do not have the content of stones and clay that is common in Neshaminy soils.

Ellington fine sandy loam, loamy subsoil variant, 3 to 8 percent slopes (ElB).—This soil has the profile described as representative of the Ellington variant. It occupies intermediate positions on long slopes. Included in mapping are small areas of poorly drained Preakness soils, somewhat poorly drained Pompton soils, and well-drained Riverhead and Neshaminy soils.

Water often saturates the subsoil, and in places wet seepage spots are on the surface after heavy rains. Water received from soils that occupy higher positions makes even these gently sloping soils moderately susceptible to erosion. In cultivated areas, contour stripcropping and diversions have been used to control erosion. Interceptor drains are effective in removing excess water. Seepage into excavations along roads, homesites, and playfields causes unstable slopes. Capability unit IIw-25.

Ellington fine sandy loam, loamy subsoil variant, 8 to 15 percent slopes (ElC).—This soil has a profile similar to the one described as representative of the Ellington variant, but it has more gravel in the surface layer. The soil occupies intermediate positions on long slopes, where it receives runoff and seepage from soils that occupy higher positions.

Included with this soil in mapping are areas of well-drained Riverhead and Neshaminy soils.

Water saturates the subsoil late in winter and in spring and causes wet spots on the surface. The combined effect of excess water and erodibility makes this strongly sloping soil highly susceptible to further erosion. It is suitable for general crops, hay, and pasture. In cultivated areas, contour cultivation, stripcropping, and diversions are effective in controlling erosion. Seepage into excavations along roads, homesites, or playfields causes unstable slopes in deep cuts. Capability unit IIIe-25.

Ellington fine sandy loam, loamy subsoil variant, 15 to 25 percent slopes (ElD).—This soil has a profile similar to the one described as representative of the Ellington variant, but the surface layer is more gravelly and the upper part of the subsoil is less prominently mottled. The soil occupies intermediate positions on long slopes, where it receives runoff from adjacent soils that occupy higher positions. Included in mapping are small areas of Riverhead and Neshaminy soils.

Water seasonally saturates the subsoil of this steep soil and causes wet spots on the surface. It is not suited to continuous cultivation of row crops. It is better suited to hay, pasture, woodland, and wildlife than to other uses. Steepness is a limitation for many community development uses. Capability unit IVe-58.

Haledon Series

The Haledon series consists of deep, gently sloping to sloping, somewhat poorly drained soils. These soils are on undulating and rolling low hills within the basin of former glacial Lake Passaic and on narrow elongated areas on the sides and tops of steep basalt ridges. They have a well-developed, firm fragipan. The soils formed in somewhat gravelly, cobbly, and stony glacial till. The

till is mostly material that was derived from red and brown shale, sandstone, and basalt, but it contains some granitic gneiss.

In a representative profile the surface layer is dark-brown silt loam about 10 inches thick. The upper part of the subsoil is brown, mottled silt loam about 8 inches thick. Below this, the subsoil is a fragipan of reddish-brown, very firm, dense silt loam that extends to a depth of about 46 inches. The substratum, to a depth of 64 inches, is dark-brown, firm very fine sandy loam.

Permeability is moderate above and below the fragipan but slow in the fragipan. These soils have a high proportion of silt and very fine sand. They have poor workability, stability, and compaction characteristics and are compressible. Depth to the seasonally perched water table ranges from ½ foot to 1½ feet. Roots are commonly distributed throughout the profile above the fragipan, but they seldom penetrate or extend into the fragipan. Available water capacity is moderate, and water stored below the fragipan is generally not available for use by plants.

Vegetation on Haledon soils consists mainly of stands of red oak, pin oak, swamp white oak, maple, and elm. Many areas have cleared and are used for pasture and hay. If the soils are adequately drained, they are suited to corn. Interceptor drains and spot drainage are effective in providing drainage.

Representative profile of Haledon silt loam, 3 to 8 percent slopes, in a residential development between Reynolds and Beverwyck Roads, three-eighths of a mile southwest of their junction, in Parsippany-Troy Hills Township:

Ap—0 to 10 inches, dark-brown (7.5YR 4/2) silt loam; moderate, fine and medium, subangular blocky and weak, medium, granular structure; very friable; many fine fibrous roots; 10 percent gravel and cobbles; medium acid; abrupt, smooth boundary. 6 to 10 inches thick.

B21t—10 to 14 inches, brown (7.5YR 5/4) silt loam; few, medium, distinct, reddish-yellow (7.5YR 7/6) mottles; moderate, medium, subangular blocky structure; friable, slightly sticky, slightly plastic; common roots; few, red, thin, patchy clay films on ped faces and bridges between grains; 10 percent small rounded stones and cobbles, 10 percent gravel, mainly red and brown shale, basalt, and granitic gneiss; strongly acid; gradual, wavy boundary. 4 to 18 inches thick.

B22t—14 to 18 inches, brown (7.5YR 5/4) heavy silt loam; common, coarse, prominent, reddish-brown (5YR 4/4) mottles and few, medium, distinct, gray (10YR 6/1) mottles; moderate, coarse, subangular blocky structure; friable, sticky, slightly plastic; common roots; pinkish-gray (7.5YR 6/2) and reddish-brown (5YR 4/4), thin to thick, discontinuous clay films on ped faces; 5 percent small rounded stones and cobbles, 10 percent gravel of red and brown shale, granitic gneiss, and traprock fragments; strongly acid; abrupt, wavy boundary. 0 to 10 inches thick.

Bx—18 to 46 inches, reddish-brown (5YR 4/4) silt loam; common, medium, prominent, black (N 2/0) mottles and few, medium, distinct, gray (10YR 6/1) mottles; weak, very thick, platy structure; very firm and brittle; few roots; black, glossy and semiglossy, patchy clay films on ped faces and coarse fragments; 10 percent gravel, 10 percent small rounded stones and cobbles, mostly red and brown shale and some granitic gneiss; strongly acid; clear, wavy boundary. 20 to 40 inches thick.

C—46 to 64 inches, dark-brown (7.5YR 4/4) very fine sandy loam; massive; firm; black stains on coarse fragments and in matrix; medium acid.

The solum ranges from 42 to 50 inches in thickness. Depth to the fragipan is 16 to 30 inches. Depth to bedrock generally is more than 5 feet. In most places the soil is 5 to 30 percent gravel, cobbles, and stones. In areas that are not limed, the solum is strongly acid. The C horizon is slightly acid or neutral.

The Ap horizon ranges from dark brown to dark grayish brown in hue of 10YR or 7.5YR, value of 4, and chroma of 2 or 3. The 1- to 3-inch A1 horizon has a value of 2 or 3.

The B2t horizon ranges from dark brown (7.5YR 4/4) to yellowish brown (10YR 5/6). Mottles range from 5YR to 2.5Y in hue, 4 to 7 in value, and 1 to 6 in chroma. Depth to low-chroma mottles ranges from 10 to 18 inches. This horizon is silt loam, loam, or fine sandy loam. The Bx horizon has weak, very thick, platy structure or is massive. In many profiles the platy structure parts to weak or moderate, medium or coarse, subangular blocky.

The C horizon is sandy loam and very fine sandy loam. In many places the upper part of the C horizon is part of the fragipan and is firm, dense and brittle, and several feet thick. In a few places the C horizon is friable and porous immediately beneath the Bx horizon.

Haledon soils are associated with Boonton, Whippany, Riverhead, and Pompton soils. They are coarser textured than the Whippany soils, which formed in lacustrine deposits. Haledon soils have a fragipan, which Riverhead and Pompton soils lack. They have low-chroma mottles nearer to the surface than Boonton soils. They are not so fine textured in the B horizon as Whippany soils nor so coarse-textured as Riverhead soils. They contain more silt than Pompton soils.

Haledon silt loam, 3 to 8 percent slopes (HaB).—This soil has the profile described as representative of the series. Included in mapping are small areas of stony Haledon soils and Whippany, Boonton, and Pompton soils.

Properties that affect use of this gently sloping soil are a seasonally perched water table, moderate runoff, and a moderate hazard of erosion. Drainage has generally been improved by interceptor drains. In farmed areas suitable erosion control practices include extensive use of cover and sod crops, contour cultivation, and stripcropping on long slopes. In residential, commercial, and industrial developments early establishment of lawns, use of a temporary grass cover during construction, and division of long slopes by use of diversions or streets help to reduce erosion and sedimentation. Capability unit IIe-71.

Haledon silt loam, 8 to 15 percent slopes (HaC).—This soil has a profile similar to the one described as representative of the series, but it has more coarse fragments on the surface. Included in mapping are small widely spaced areas of cobbly and stony Boonton soils and the Ellington variant.

This strongly sloping soil has a likelihood of lateral seepage over the fragipan, slow permeability, rapid runoff, moderate available water capacity, and a severe hazard of erosion. On farmland, contour stripcropping, diversions, and frequent use of sod or close-growing crops help to control erosion and runoff. Interceptor drains and spot drainage are effective in providing adequate drainage. If this soil is used for community development, use of temporary grass cover to protect cleared areas during construction, early establishment of grass cover, and division of long slopes by use of diversions or cross streets help to control erosion and

runoff. Construction of desilting basins and installation of interceptor drains and retaining walls are special measures to control runoff and erosion and to stabilize slopes in residential, commercial, and industrial developments. Capability unit IIIe-71.

Hibernia Series

The Hibernia series consists of deep, gently sloping to steep, somewhat poorly drained soils in depressions, in watercourses, and at the base of steep slopes. These soils have stones on the surface and a fragipan. They formed in glacial till and colluvium derived from such deposits. The material has a mixed composition dominated by granitic gneiss but contains a small amount of many other kinds of rock.

In a representative profile the surface layer is very dark gray gravelly loam about 2 inches thick. The subsurface layer is yellowish-brown gravelly loam about 5 inches thick. The upper part of the subsoil is yellowish-brown and dark yellowish-brown gravelly sandy loam about 13 inches thick, and the lower part is a fragipan of strong-brown and dark-brown, very firm gravelly sandy loam about 10 inches thick. The upper 16 inches of the substratum is part of the fragipan and is light-gray, very firm gravelly sandy loam. Below this the substratum, to a depth of 60 inches, is brown and pale-brown stony sandy loam.

Permeability is moderate above the fragipan and slow in the fragipan. These soils have good workability, stability, and compaction characteristics; low subsidence; and low compressibility. Depth to the seasonal high water table is ½ foot to 1½ feet late in winter and early in spring. In addition, water is locally perched on top of the fragipan. This water is held in the soil and moves laterally over the fragipan. Roots are commonly distributed throughout the soil above the fragipan. The available water capacity is low, and water stored below the fragipan is generally not available for use by plants. The hazard of erosion is moderate to severe, depending on slope. The slow permeability in the fragipan is a limitation to onsite disposal of septic tank effluent. Water seeping laterally on top of the fragipan is likely to move into foundations and to the surface at steep cuts for roads and houses, causing drainage problems and unstable banks.

Most areas of Hibernia soils are woodland.

Representative profile of Hibernia gravelly loam in an area of Hibernia stony loam, 3 to 15 percent slopes, in the northeast corner of a mine pit, 400 yards south of Snake Hill Road, one-half mile west of Route 513, in Rockaway Township:

A1—0 to 2 inches, very dark gray (10YR 3/1) gravelly loam; weak, fine, granular structure; friable; many, fine, fibrous roots and common conductor roots; peds and sand grains have coatings of very dark gray; 25 percent gravel and cobbles and a few stones; very strongly acid; abrupt, wavy boundary. 1 to 4 inches thick.

A3—2 to 7 inches, yellowish-brown (10YR 5/6) gravelly loam; weak, medium and fine, subangular blocky structure; friable; many, fine, fibrous roots and common conductor roots; most sand grains clean or only slightly stained; 25 percent gravel and cobbles and a few stones; strongly acid; clear, wavy boundary. 2 to 10 inches thick.

B21t—7 to 14 inches, yellowish-brown (10YR 5/6) gravelly sandy loam; weak, medium, subangular blocky structure; friable; common, fine, fibrous roots; thin strong-brown (7.5YR 5/8) clay bridges between sand grains; 30 percent gravel, cobbles, and stones derived largely from granitic rock but having a small quantity of other rock types, some coarse fragments distinctly weathered and soft; strongly acid; gradual, wavy boundary. 6 to 20 inches thick.

B22t—14 to 20 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam; few, medium, distinct, light-gray (10YR 7/2) mottles and a few, medium, prominent, yellowish-red (5YR 5/8) mottles as stains that fade into the matrix color; weak, medium, subangular blocky structure; friable; common, fibrous roots throughout concentrated along lower boundary; thin patchy clay films on peds and bridges between sand grains; 30 percent gravel, cobbles, and stones; very strongly acid; clear, wavy boundary. 0 to 12 inches thick.

Bx—20 to 30 inches, nearly equal proportions of strong-brown (7.5YR 5/8) and dark-brown (7.5YR 4/4) gravelly sandy loam; many, coarse, distinct, pinkish-gray (7.5YR 6/2) mottles; weak, thick, platy structure; very firm; dense pores and voids partly filled with fines; thick, glossy, yellowish-red (5YR 5/8), patchy clay films on some peds; 30 percent cobbles, gravel, and stones; very strongly acid; diffuse, wavy boundary. 6 to 18 inches thick.

C1x—30 to 46 inches, light-gray (10YR 7/2) gravelly light sandy loam; many, coarse, prominent, yellowish-red (5YR 5/8) and brownish-yellow (10YR 6/8) mottles; massive; very firm and brittle; 35 percent cobbles, gravel, and stones; very strongly acid; abrupt, wavy boundary. 0 to 18 inches thick.

C2—46 to 60 inches, brown (10YR 5/3) and pale-brown (10YR 6/3) stony sandy loam; massive; very friable; 50 percent stones, cobbles, and gravel; very strongly acid.

The solum ranges from 24 to 40 inches in thickness. Depth to bedrock is more than 10 feet. Depth to the fragipan ranges from 18 to 30 inches, and thickness of the fragipan ranges from 12 to 30 inches. The fragipan is restricted to the B horizon in some places. These soils are always dominated by granitic material and have a high proportion of coarse sand. The solum is 20 to 50 percent gravel and cobbles and 3 to 15 percent stones and boulders in any subhorizon, but the weighted percentage is less than 35. In addition to granitic material, quartzite, sandstone, and shale are also present. In areas that are not limed, reaction is strongly acid to very strongly acid throughout.

The Ap horizon ranges from very dark gray to dark brown in hue of 10YR or 7.5YR, value of 4, and chroma of 1 to 3. The A1 horizon has similar colors but ranges to 3 in value. The dominant texture is gravelly loam or gravelly sandy loam, but in most places the soil is stony or very stony.

The matrix of the Bt horizon ranges from yellowish brown to dark brown in hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 4 to 6. This horizon is commonly gravelly sandy loam and is generally more or less cobbly and stony. Low-chroma mottles are at a depth of 12 to 24 inches. The fragipan is massive or has weak, thick, platy structure in most places, but it ranges to strong, thick, platy.

In most places the C horizon has a hue of 10YR, value of 5 to 7, and chroma near 3, but higher chromas are common where the horizon is slightly weathered. This horizon is massive or has weak, thick, platy structure. It ranges from very firm to loose.

Hibernia soils are associated with the well drained and moderately well drained Rockaway soils, the well drained Netcong soils, and the poorly drained Ridgebury soils. They have low-chroma mottles, which Rockaway and Netcong soils lack. Hibernia soils do not have the low-chroma matrix colors that are common in Ridgebury soils.

Hibernia stony loam, 3 to 15 percent slopes (HbC).—This soil has the profile described as representative of

the series. Stones cover 0.01 to 0.1 percent of the surface and are spaced 30 to 100 feet apart. The soil is on gently undulating or rolling topography or in depressions or waterways in areas of such topography. Included in mapping are areas of Rockaway, Netcong, and Ridgebury soils and less sloping and more sloping Hibernia soils.

Use of this soil is limited by cobbles, stones, and boulders throughout the profile; slow permeability in the fragipan; moderate to rapid runoff; and a slight to moderate hazard of erosion. This soil is suited to hay and pasture. If it is used for farming and most community developments, improved drainage, control of runoff and erosion, and removal of stones are needed. In farmed areas, spot and interceptor drainage by ditches or tiles are beneficial but are generally difficult to install because of the uneven topography, moderate depth to the fragipan, and stoniness. Diversions and crop rotations help to control erosion and runoff. If this soil is used for community developments, planting temporary cover to protect rolling slopes cleared during construction, early seeding of new lawns or other plant cover, use of diversions to divide long slopes or above steep cuts or banks, and temporary desilting basins are beneficial in reducing erosion and sedimentation. Capability unit IVs-34.

Hibernia very stony loam, 15 to 25 percent slopes (HlD).—This soil has a profile similar to the one described as representative of the series, but it has a higher proportion of stones and boulders distributed over the surface. Stones occupy 0.1 to 3 percent of the surface and are spaced 5 to 30 feet apart. The soil is in narrow, hilly areas where seepage comes close to the surface.

Included with this soil in mapping are areas of Rockaway, Netcong, and less sloping Hibernia soils. Also included are extremely stony and bouldery spots.

This steep soil has rapid runoff and an abundance of cobbles, stones, and boulders distributed over the surface and through the soil. Permeability is slow in the fragipan. The hazard of erosion is severe in cleared areas, but not much of the soil has been cleared for farming.

This soil is used mainly for trees recreation, and wildlife habitat. The trees are mostly oak, birch, ash, and hickory. Much of the acreage that was cleared for farming has been abandoned and now supports stands of young hardwoods. Slopes generally are too steep for normally spaced residential developments, but a few areas are suitable for individual homesites. Sequential clearing, planting temporary cover on cleared areas during construction, early seeding of new lawns and other plant cover, use of diversions or cut-off drainage to intercept seepage water, and use of temporary desilting basins are beneficial in controlling erosion and sedimentation. Stones are a limitation to use of this soil for many purposes. Capability unit VIs-34.

Holyoke Series

The Holyoke series consists of shallow, gently sloping to steep, well-drained soils. These soils are in elongated areas along the slopes of the basalt ridges. They formed on glacially scoured trap ridges in thin discontinuous deposits of glacial till that was derived mainly from basalt, red and brown shale, and sandstone but contains a small amount of granitic gneiss and many kinds of quartzitic sandstone, shale, and conglomerate. Stones and boulders occur throughout the soil but are concentrated on the surface, especially where the soils are steeper. Rock outcrop makes up 2 to 50 percent of each area mapped but are larger and more common on steeper slopes.

In a representative profile the surface layer is dark-brown gravelly silt loam about 2 inches thick. The upper part of the subsoil is strong-brown gravelly silt loam about 4 inches thick, and the lower part is brown cobbly silt loam about 11 inches thick. Hard basalt bedrock is at a depth of 17 inches.

Permeability is moderate, and available water capacity is low. These soils are shallow to bedrock. Rock outcrops are common, and the proportion of coarse fragments is high. The shallow depth to bedrock limits the rooting zone, and the high proportion of coarse fragments within this zone further limits the available water capacity of these soils.

Holyoke soils are generally unsuited to crops. They are used mostly for pasture, woodland, and wildlife. For community development or intensive recreational uses, the shallowness to bedrock and the high proportion of coarse fragments are limitations that affect excavations for foundations or grading purposes. The bedrock is hard but is fractured into large angular equidimensional blocks. Excavating without blasting is extremely difficult. Most areas are woodland.

Representative profile of Holyoke gravelly silt loam in an area of Holyoke rocky silt loam, 5 to 15 percent slopes, on the north side of the Route 80 right-of-way, just west of Hook Mountain Road:

A1—0 to 2 inches, dark-brown (7.5YR 3/2) gravelly silt loam; moderate, medium, granular structure; friable; many roots; 10 percent stones, 5 percent cobbles, and 15 percent gravel, mostly angular blocks of traprock, red and brown shale, and granitic gneiss; very strongly acid; clear, wavy boundary. 1 to 3 inches thick.

B1—2 to 6 inches, strong-brown (7.5YR 5/6) gravelly silt loam; weak, fine, granular structure; friable; many roots; many, clean, uncoated sand grains; 30 percent stones, cobbles, and gravel; very strongly acid; gradual, wavy boundary. 2 to 6 inches thick.

B2—6 to 17 inches, brown (7.5YR 4/4) cobbly silt loam; weak, fine, subangular blocky structure; friable when moist, slightly plastic when wet; many roots; 30 percent stones, cobbles, and gravel; nearly all sand grains stained or coated; very rare, isolated, patchy, semiglossy coatings in some voids; very strongly acid; abrupt, wavy boundary. 10 to 16 inches thick.

R—17 inches, glacial scoured basalt bedrock; widely spaced zones are shattered or fractured to a depth of 10 feet or more.

Thickness of the solum and depth to bedrock range from 12 to 20 inches. The bedrock in most places is hard massive basalt, but in places the basalt is shattered and fractured to a depth of 10 feet or more. Most areas are rocky. Loose boulders, stones, cobbles, and gravel occur throughout the profile, and they make up 5 to 35 percent of the soil mass. The solum is generally silt loam, very fine sandy loam, or loam that is mostly near the silt loam-loam textural bound-

ary. In areas that are not limed, reaction ranges from very strongly acid to strongly acid throughout.

The B horizon ranges from 7.5YR to 5YR in hue. In most places the upper part has value of 5 or 6 and chroma of 4 to 6. The lower part, where hue of 5YR is more common, has value of 4 or 5 and chroma of 4.

Holyoke soils are associated with Boonton and Haledon soils but are shallower to bedrock than those soils.

Holyoke rocky silt loam, 5 to 15 percent slopes (HoC).—This soil has the profile described as representative of the series. It commonly is 2 to 10 percent Rock outcrop but ranges to 25 percent in a few areas. Included in mapping are areas of Boonton and Haledon soils and steeper Holyoke soils.

Shallowness to bedrock, rock outcrops, coarse fragments, and complex rolling slopes are limitations to use of this soil for farming and community development.

This soil is generally poorly suited to cultivation. It is better suited to pasture, woodland, and wildlife habitat than to other uses. Generally limitations are severe for residential development, but it is used extensively as sites for custom homes. Excavating is generally difficult and expensive. Erosion, runoff, and sedimentation are moderate hazards during and after construction of homes. Suitable practices that help to reduce erosion and sedimentation are using a temporary grass cover on cleared areas, stockpiling soil during construction, establishing lawns early after construction, and designing waterways to provide safe overland flow of surface water. Capability unit VIs-17.

Holyoke-Rock outcrop complex, 15 to 35 percent slopes (HrE).—This complex is about 50 to 65 percent Holyoke rocky silt loam and 35 to 50 percent Rock outcrop and some short rock escarpments. The Holyoke soils have the profile described as representative of the series. Included in mapping are small areas of steeper, less rocky, less stony Holyoke soils and some small areas of Boonton and Haledon soils.

Shallowness to bedrock, rock outcrops, coarse fragments, and steepness severely limit the use of this complex.

This complex is not suited to cultivation, but it is suited to pasture and woodland. Limitations are severe for many community developments. In places custom-built homes can be placed between the rocks. Access roads and septic systems are generally extremely expensive to install, and excavating is difficult and expensive. Erosion, runoff, and sedimentation are severe hazards during and after development. Suitable practices that help to reduce these hazards are using temporary grass cover in cleared areas, establishing lawns early after construction, giving special attention to stabilizing critical areas, such as steep cuts and waterways, and constructing temporary or permanent desilting basins. Capability unit VIIs-22.

Klinesville Series

The Klinesville series consists of shallow, very steep, well-drained shaly soils in long, narrow escarpments that extend along steep valleysides. These soils formed in material weathered from shale bedrock. The exposed bedrock is very susceptible to physical weathering but not to chemical weathering. In many places the upper layers of bedrock are broken into shale chips to a considerable depth but otherwise are little changed.

In a representative profile the surface layer is dark reddish-brown shaly silt loam about 2 inches thick. The subsoil is reddish-brown very shaly silt loam that grades gradually into fractured shale bedrock at a depth of about 14 inches. The percent of shale fragments and the size and hardness of the shale chips increase with increasing depth. The transition to bedrock is so gradual that it is difficult to distinguish between shaly soil material and fractured bedrock.

Representative profile of Klinesville shaly silt loam, 25 to 35 percent slopes, in a wooded area overlooking Silver Lake, one-eighth mile upstream from Blue Mill Road, in Harding Township:

A1—0 to 2 inches, dark reddish-brown (5YR 3/2) shaly silt loam; moderate, medium, crumb structure; friable; many, fine, fibrous roots and large feeder roots; 25 percent shale chips that range from ¼ inch to 2 inches in diameter and from ⅛ inch to ½ inch in thickness; strongly acid; clear, smooth boundary. 1 to 3 inches thick.

B—2 to 14 inches, reddish-brown (5YR 4/3) very shaly silt loam; structure is masked by a high proportion of coarse fragments; friable; slightly sticky; 50 percent coarse fragments that increase in size, quantity, and hardness with increasing depth; medium acid; diffuse, wavy boundary. 10 to 18 inches thick.

R—14 inches, reddish-brown (5YR 4/3) shale chips and flagstones in place that increase in size and hardness with increasing depth.

Thickness of the solum and depth to shale bedrock range from 10 to 20 inches. Some profiles have a C horizon. Shale fragments make up 15 to 60 percent of the solum and 50 to 90 percent of the C horizon. Roots occur throughout the profile and extend into the bedrock along joints and fractures. In areas that are not limed, reaction ranges from strongly acid to medium acid throughout.

The A1 horizon ranges from reddish brown (2.5YR 4/4) to dark brown (7.5YR 3/2). The Ap horizon has a hue similar to that in the A horizon but value ranges to 2 and chroma to 1.

The B horizon is 10R to 5YR in hue, 3 or 4 in value, and 3 to 6 in chroma.

The C horizon, where present, is 10R to 5YR in hue, 3 or 4 in value, and 4 in chroma. This horizon is very shaly silt loam or loam in most places but ranges to material that is almost entirely shale chips. This horizon ranges from 2 to 6 inches in thickness.

The bedrock is generally thinly bedded, fractured shale or, in a few places, sandstone.

Klinesville soils are associated with Penn, Reaville variant, and Neshaminy soils. Klinesville soils are not so deep as those soils. They do not have the mottles that are common in the Reaville variant.

Klinesville shaly silt loam, 25 to 35 percent slopes (KlE).—Included with this soil in mapping are areas of less sloping Klinesville and Penn soils. Areas of shale rock outcrop, which make up 2 percent of the mapped areas, are included. Also included are areas of Neshaminy soils and some small low rock escarpments.

Permeability is moderately rapid, and available water capacity is low. The rooting zone is shallow.

Because of its steep slopes, shallowness, droughtiness, and susceptibility to erosion, this soil is better suited to uses that provide a permanent cover of drought-tolerant grasses, trees, and shrubs. Shallowness to bedrock and the very steep slopes severely limit this soil for most community developments. In most places

the bedrock is easily excavated with light equipment. This soil is mostly used for pasture. Capability unit VIIe-66.

Made Land, Sanitary Land Fill

Made land, sanitary land fill (Ma) consists of fill material that varies widely in composition and physical characteristics. The characteristics depend on the kind and proportion of refuse disposed of, the kind and amount of soil material used to cover the refuse, and the particular kind of landfill operation that was practiced.

Generally the fill material includes trash, garbage, building material, and, in places, industrial waste. Normal operation requires compaction while filling and a cover of 2 feet of soil over the final fill. Formation of gases and leachate is likely, and differential settling limits the use of this land for many purposes.

The properties of sanitary land fill are so varied that intense onsite investigation is needed to determine its properties and potential uses. Not assigned to a capability unit.

Minoa Series

The Minoa series consists of deep, nearly level to gently sloping, somewhat poorly drained soils. These soils are on slightly elevated areas within and at the margins of former glacial Lake Passaic. The areas are recessional beaches or terraces formed by wave action or currents working on older lake sediment. The soils formed in lacustrine sediment. The sediment is so thick that the depth to and the kind of underlying bedrock are uncertain. It is variable from place to place but includes red and brown shale, sandstone, and basalt.

In a representative profile the surface layer is silt loam about 6 inches thick. The upper 3 inches is very dark grayish-brown, and the lower 3 inches is yellowish brown. The upper part of the subsoil, about 12 inches thick, is strong-brown silt loam mottled with strong brown and light brownish gray. The middle part, about 6 inches thick, is strong-brown and yellowish-brown silt loam mottled with pale brown, light yellowish brown, and reddish yellow. The lower part of the subsoil, about 6 inches thick, is pale-brown varved fine sandy loam and silt loam mottled with strong brown, light brownish gray, and yellowish red. The substratum, to a depth of about 48 inches, is brown loamy fine sand. Below this, to a depth of 60 inches, it is reddish brown with varves of pinkish-gray, pale-brown, reddish-yellow, brownish-yellow, and yellowish-brown silt loam, loamy fine sand, and loamy very fine sand.

Permeability is moderately slow or moderate. These soils have poor workability, poor stability, and poor compaction characteristics because of a very high content of silt or very fine sand. The available water capacity is high. The water table is ½ foot to 1½ feet from the surface late in winter or early in spring and after heavy rain. During summer the water table drops to a depth of 3 or 4 feet.

The native vegetation is swamp maple, sweetgum, pin oak, elm, hickory, and swamp white oak. If these soils are cleared, they can be used for hay or pasture, particularly species suited to wet areas. Intensive cultivation and community development require improved drainage. Most areas are woodland.

Representative profile of Minoa silt loam, 0 to 3 percent slopes, along a ditchbank at the north end of Spring Brook Country Club and the southern edge of a housing development, 800 feet southeast along woods line from U.S. Route 202, near the boundary of the town of Morristown:

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, medium, granular structure; very friable; many, fine, fibrous roots; strongly acid; clear, smooth boundary. 1 to 3 inches thick.

A3—3 to 6 inches, yellowish-brown (10YR 5/4) silt loam; weak, medium and fine, subangular blocky structure; very friable; many, fine, fibrous roots; old worm and root channels filled with very dark grayish-brown (10YR 3/2) material from the A1 horizon; many sand grains clean and uncoated, but most pores filled; strongly acid; clear, wavy boundary. 0 to 6 inches thick.

B1—6 to 18 inches, strong-brown (7.5YR 5/6) silt loam; few, fine, faint, strong-brown (7.5YR 5/8) mottles and distinct light brownish-gray (10YR 6/2) mottles; weak, medium and fine, subangular blocky structure; friable, slightly sticky; common, fine, fibrous roots; some small pockets one-half inch in diameter in the upper part of this horizon filled with leached sand grains; horizon deepens in color with increasing depth, and sand grains in lower part coated or stained; strongly acid; clear, smooth boundary. 3 to 12 inches thick.

B21—18 to 24 inches, nearly equal proportions of strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/4) silt loam; common, coarse, distinct, pale-brown (10YR 6/3) mottles, common, medium, faint, light yellowish-brown (10YR 6/4) mottles, and common, medium, faint, reddish-yellow (7.5YR 6/8) mottles; weak, medium, subangular blocky structure; firm to friable when moist, slightly sticky and slightly plastic when wet; common, fine, fibrous roots decrease with increasing depth; brownish mottles slightly finer in texture and discontinuous semiglossy films on some peds and in some voids; strongly acid; diffuse, wavy boundary. 0 to 10 inches thick.

B22—24 to 30 inches, pale-brown (10YR 6/3) varved fine sandy loam and silt loam; many, coarse, distinct, strong-brown (7.5YR 5/8) mottles, common, medium, faint, light brownish-gray (2.5Y 6/2) mottles, and common, medium, faint, yellowish-red (5YR 5/6) mottles; weak, medium, subangular blocky structure; firm to friable; brown color is distinct and occurs in bands associated with textural varving, in the lower part many grains are unstained; strongly acid; diffuse, wavy boundary. 6 to 14 inches thick.

IIC—30 to 48 inches, brown (7.5YR 5/4) loamy fine sand; many, coarse, faint, strong-brown (7.5YR 5/6) mottles; massive; firm to friable and brittle; strongly acid; abrupt, wavy boundary. 12 to 36 inches thick.

IIIC—48 to 60 inches, reddish-brown (5YR 5/4) varved silt loam, loamy fine sand, and loamy very fine sand; varves of pinkish gray (7.5YR 6/2), pale brown (10YR 6/3), reddish yellow (7.5YR 6/8), brownish yellow (10YR 6/8), and yellowish brown (10YR 5/4); friable to firm; neutral.

The solum ranges from 24 to 40 inches in thickness. These soils are dominantly silt loam throughout the solum and have a high proportion of fine or very fine sand. Coarse fragments are rare or lacking.

The A1 horizon is commonly 7.5YR or 10YR in hue, 3 or 4 in value, and 2 or 3 in chroma.

The B horizon ranges from 7.5YR to 10YR in hue, 4 to 6

in value, and 4 to 8 in chroma. It has a slightly higher content of clay than the A and C horizons. Mottles are 5YR to 2.5Y in hue, 5 to 6 in value, and 2 to 8 in chroma.

The C horizon is commonly 5YR to 7.5YR in hue, 5 or 6 in value, and 3 or 4 in chroma and rarely ranges to a chroma of 6. This horizon is commonly loamy fine sand or silt loam but ranges to include varves as fine as silty clay loam or as coarse as sandy loam. Mottles are 5YR to 10YR in hue, 5 or 6 in value, and 2 to 8 in chroma. In places the horizon consists of thick, uniform strata of silt loam or loamy fine sand. In other places it is so finely stratified as to be varved. The upper part of the C horizon in many places is strongly acid, but in all places the C horizon becomes less acid with increasing depth and in most places is neutral to slightly alkaline within 48 inches of the surface.

Minoa soils are associated with Whippany, Parsippany, and Pompton soils. They do not have the clay content in the B horizon that is common in Whippany and Parsippany soils. They do not have the medium and coarse sand that is common in Pompton soils.

Minoa silt loam, 0 to 3 percent slopes (MlA).—This soil has the profile described as representative of the series. Included in mapping are small areas of soils that are similar to this Minoa soil but have a finer textured subsoil, more sloping Minoa soils, Parsippany soils, and Whippany soils.

Undrained areas of this soil are used for woodland, pasture, and hay. Drained areas are suited to corn and high-value vegetables. If this soil is used for crops and community development, improved drainage is necessary. Because of the low position of this soil, adequate outlets in many places are difficult to obtain. Where outlets are available, surface ditches are effective in removing excess water. Because of its high content of silt or very fine sand and somewhat poor drainage, this soil has a high potential frost action. Capability unit IIIw-70.

Minoa silt loam, 3 to 8 percent slopes (MlB).—This soil has a profile similar to the one described as representative of the series, but in many areas the surface layer is lighter colored. The soil is in elongated, often serpentine-shaped areas that commonly are impractical to manage separately from the surrounding soils. It generally is at the base of slopes at the margin of Passaic Basin, where it receives runoff and seepage from soils that occupy higher positions. It also has a seasonally moderately high water table.

Included with this soil in mapping are areas of Pompton and Whippany soils and soils that are similar to this Minoa soil but have a finer textured subsoil.

Because of its high content of silt and very fine sand and the seepage of water from adjacent soils, this soil has a high potential frost action. Undrained areas of this soil are used for woodland, pasture, and hay. Drained areas are suited to corn. If this soil is used for community development, improved drainage is needed. A combination of surface ditches and diversions or interceptor drains are suitable practices that help to improve drainage. Capability unit IIIw-70.

Muck

Muck is decomposed organic material in thick layers. It is underlain by mineral material at a depth of 16 to 50 inches. Although permeability is rapid in the organic layer, drainage is poor.

The water table is at the surface nearly all year. Muck is subject to flooding.

Muck is not suited to community development. Its suitability for farming is limited. Most areas are woodland.

Muck, shallow over clay (Ms).—This nearly level, very poorly drained soil consists of organic material that is 16 to 50 inches deep over a substratum of clay. The organic material is highly decomposed to slightly decomposed, fibrous and granular, woody, herbaceous material. This soil is commonly around margins of bogs and swamps surrounding areas of Carlisle muck, mainly in the eastern part of the county in basins formerly occupied by glacial Lake Passaic. Depth to bedrock is generally more than 10 feet.

Permeability is rapid in the organic layer and slow in the substratum. The organic layer is medium acid to neutral in reaction. The available water capacity is high. The water table is at the surface nearly all year. This soil is in low positions, and it is subject to frequent flooding.

Included with this soil in mapping are areas of Carlisle muck; Adrian muck; Muck, shallow over loam; and Parsippany, Preakness, and Biddeford soils.

This soil is generally unsuited to most community developments because of its high water table, hazard of flooding, unstable organic material, and clay substratum. It has potential for farming but needs drainage. Drainage outlets are generally unavailable, very costly, or difficult to obtain. Most areas are woodland. Capability unit VIIw-41.

Muck, shallow over loam (Mu).—This very poorly drained, nearly level soil is in depressions and along streams. It consists of organic material that is 16 to 50 inches deep over a substratum of stratified silt loam, loam, or silt clay loam. The organic material is highly decomposed to slightly decomposed, fibrous and granular, woody, herbaceous material. Depth to bedrock is 10 feet or more.

Included with this soil in mapping are small areas of Carlisle muck; Adrian muck; Muck, shallow over clay; and Parsippany, Preakness, and Biddeford soils.

In areas that are not limed, reaction is strongly acid to medium acid. Permeability is rapid in the organic layer and moderate or moderately slow in the substratum. Available water capacity is high. In undrained areas, the water table is at or near the surface throughout the year. Areas in small depressions are frequently ponded, and those along streams are subject to flooding. In drained areas the organic layer subsides as it dries. This layer has low bearing strength.

This soil is poorly suited to most community developments, but it is used for dug ponds or impoundments. The moderate depth of the organic material and poor drainage limit the use of this soil for farming. Some attempts have been made to drain and farm this soil, but because of limited adequate outlets, subsidence, and the moderate depth of the organic material, most attempts have failed. Because of high land values and urbanization pressures, it is unlikely that extensive areas of this soil will be farmed. Most areas are woodland. Capability unit VIIw-41.

Neshaminy Series

The Neshaminy series consists of deep, gently sloping to steep, well-drained gravelly and stony soils. These soils are on the top and sides of the traprock ridges and on hills south of the terminal moraine of the Wisconsin glaciation. They formed in material weathered from the underlying basalt bedrock, and the content of coarse fragments generally increases with depth.

In a representative profile the surface layer is dark-brown gravelly silt loam about 8 inches thick. The upper part of the subsoil, to a depth of about 11 inches, is reddish-brown gravelly clay loam. The middle 12 inches of the subsoil is yellowish-red gravelly clay loam, and the lower 31 inches is yellowish-red cobbly clay loam. The substratum to a depth of 60 inches is yellowish-red sandy loam and weathered fragments of basalt.

Permeability and available water capacity are moderate. These soils are susceptible to frost heave and are difficult to work during cold months.

Most areas of the gently sloping soils were formerly cleared and farmed, but most areas have been abandoned, and the fields have reverted to trees. Yellow-poplar, oaks, hickory, and ash are the dominant trees. In places redcedar is abundant in the early stages of succession. In recent years developing communities have expanded onto the traprock ridges, and these soils are now highly regarded as residential areas. Neshaminy soils are slightly erodible to severely erodible, depending on the steepness of the slope and the amount of vegetative cover. Practices to help control runoff, erosion, and sediment are used on farms and in residential areas. The hard bedrock is difficult to excavate without blasting.

Representative profile of Neshaminy gravelly silt loam, 8 to 15 percent slopes, in the middle of a hayfield, 1,400 feet west of the junction of North Long Hill Road, Long Hill Road, and Mountain Avenue, 740 feet north of Long Hill Road, in Passaic Township:

Ap—0 to 8 inches, dark-brown (7.5YR 4/2) gravelly silt loam; moderate, medium, granular structure; friable; many, fine, fibrous roots; 15 percent angular basalt gravel; medium acid; abrupt, smooth boundary. 6 to 8 inches thick.

B1—8 to 11 inches, reddish-brown (5YR 4/4) gravelly clay loam; moderate, fine and medium, subangular blocky structure; friable; many fine fibrous roots; 15 percent angular gravel, many of which are strongly weathered; medium acid; gradual, wavy boundary. 3 to 7 inches thick.

B21t—11 to 23 inches, yellowish-red (5YR 4/6) gravelly clay loam; moderate, medium and coarse, subangular blocky structure; friable; common roots; 20 percent angular basalt cobbles and gravel; nearly continuous, thin to thick, waxy clay films on ped faces and nearly all sand grains are coated; medium acid; diffuse, wavy boundary. 3 to 12 inches thick.

B22t—23 to 39 inches, yellowish-red (5YR 4/6) cobbly clay loam; many, medium, distinct, black (5YR 2/1), semiglossy stains on ped faces and coarse fragments; weak, coarse, subangular blocky structure; firm when dry, slightly sticky and slightly plastic when wet; common roots increase in size and number with increasing depth; 30 percent coarse fragments, mostly angular basalt cobbles and gravel; slightly darker, waxylike, thin to thick, discontinuous clay films on ped faces; medium acid; gradual, wavy boundary. 10 to 25 inches thick.

B3—39 to 54 inches, yellowish-red (5YR 4/6) cobbly clay loam; massive; friable; 40 percent coarse fragments of angular cobbles and gravel composed of basalt; thick waxylike clay films in channels and voids and rarely as bridges between sand grains; medium acid; diffuse, wavy boundary. 10 to 15 inches thick.

C—54 to 60 inches, yellowish-red (5YR 4/6) sandy loam and weathered soft basalt gravel and cobble-size fragments; massive; friable; medium acid.

The solum ranges from 40 to 54 inches in thickness. Depth to bedrock ranges from 4 to 10 feet, but in less sloping areas it is more than 6 feet. Angular coarse fragments generally occur throughout the soil and range from 10 percent to 50 percent gravel, cobbles, and stones. In areas that are not limed, reaction is medium acid.

The A horizon has hue of 10YR or 7.5YR, value of 3 or 4, and chroma of 2 to 4.

The B horizon is 7.5YR to 5YR in hue, 4 or 5 in value, and 4 to 6 in chroma. This horizon has more clay than the A horizon.

The C horizon is commonly more than 50 percent coarse fragments, but in many places it consists of soft weathered saprolite and contains a few hard fragments of basalt.

Neshaminy soils are associated with Ellington variant, Klinesville, Penn, and Boonton soils. Neshaminy soils do not have the mottles that are common in Ellington and Boonton soils. They are deeper than Klinesville and Penn soils.

Neshaminy gravelly silt loam, 3 to 8 percent slopes (NeB).—This soil is in long narrow areas on the crests of the Watchung Mountains in the southern part of the county. Included in mapping are small areas of more stony Neshaminy soils, soils that are similar to this Neshaminy soil but have a mottled subsoil, the Ellington loamy subsoil variant, and Rock outcrop.

In places this soil contains a few cobbles, stones, and boulders and has moderate runoff and a moderate hazard of erosion.

This soil is well suited to farming. It has moderate limitations, and practices are needed to help control runoff, erosion, and sedimentation. Good management includes such practices as using crop rotation, cover crops, and contour cultivation. In places stripcropping is needed on long slopes. Most high-value crops are irrigated. This gently sloping soil is desirable for community development because it is deep and fertile and has good surface drainage and only a moderate hazard of erosion. Practices are needed to help control runoff, sedimentation, and erosion for this use. Among the suitable practices are early establishment of lawns, sequential development of large tracts so that only a small part of the soil is bare and exposed at any one time, and special seeding, fertilizing, and mulching in critical areas, such as waterways. Capability unit IIe-55.

Neshaminy gravelly silt loam, 8 to 15 percent slopes (NeC).—This soil has the profile described as representative of the series. Included in mapping are small areas of more stony and more sloping Neshaminy soils, the Ellington loamy subsoil variant, and soils that are similar to this Neshaminy soil but have gray mottles in the subsoil. Also included are small areas of bedrock outcrop.

This soil generally contains a few cobbles and in places stones and boulders. It has rapid runoff and a moderately severe hazard of erosion.

This soil is well suited to hay, pasture, and row crops but requires complex measures to control runoff, reduce

erosion, and minimize sediment damage to downstream areas. As a part of good management, a crop rotation, contour cultivation, stripcropping, and diversions have been used. If the soil is used for community development, practices to control runoff, erosion, and sedimentation are needed. Among the suitable practices are growing a temporary vegetative cover during development; early planting of lawns; sequential development of large tracts to keep bare areas to a minimum; special attention to critical areas, such as overland drains and waterways; and use of temporary or permanent sediment basins. Capability unit IIIe-55.

Neshaminy very stony silt loam, 15 to 25 percent slopes (NfD).—This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner, the soil is shallower to bedrock, and the proportion of stones, cobbles, and gravel is higher throughout the profile. In places there are boulders. Depth to bedrock is as little as 4 feet. Stones cover 1 to 2 percent of the surface and are spaced 5 to 30 feet apart.

Included with this soil in mapping are short, very steep areas; areas of stony or gravelly Neshaminy soils; and a few rock outcrops on short low escarpments.

Runoff is rapid, and the hazard of erosion is moderately severe.

Use of this soil is limited to hay, pasture, and woodland. Limitations for community development are severe. If the soil is used for community development, practices to control runoff, erosion, and sedimentation are needed during development. Among the suitable practices are growing a temporary vegetative cover, early establishment of lawns, sequential development of large tracts to keep bare areas to a minimum, and special attention to critical areas, such as overland drains and waterways. Special consideration should be given to construction of temporary or permanent desilting or sediment basins. Capability unit VIs-61.

Netcong Series

The Netcong series consists of deep, gently sloping to strongly sloping, well-drained soils. These soils are on rolling uplands in a narrow belt on the front of the terminal moraine that extends from the plateau west of Budd Lake, across the central part of the county, and through southern Dover to Morris Plains. They formed in moderately weathered, somewhat gravelly and cobbly sandy loam glacial till that was derived mainly from granitic gneiss but contains a small amount of other rocks. Some stones and boulders are scattered on the surface and within the soil.

In a representative profile the surface layer is very dark grayish-brown gravelly sandy loam about 7 inches thick. The upper part of the subsoil is about 6 inches of dark yellowish-brown gravelly sandy loam, the middle is about 17 inches of strong-brown gravelly sandy loam, and the lower 11 inches is yellowish-brown sandy loam. The substratum to a depth of 60 inches is light yellowish-brown sandy loam.

Permeability is moderately rapid to a depth of about 50 inches and rapid below. The available water capacity is moderate.

The native vegetation is mainly red, white, scarlet, and black oaks; hickory; and a few beech. Ash and yellow-poplar are also common. Nearly all areas of Netcong soils have been cleared and used for crops, but recently many areas have been left idle. At present, the areas are used mainly for hay and pasture.

Representative profile of Netcong gravelly sandy loam, 3 to 8 percent slopes, near Budd Lake on the edge of a borrow pit along the north side of Shore Road, 500 feet east of Budd Lake Heights Road:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) gravelly sandy loam; strong, medium, granular structure; very friable; many roots; 25 percent coarse fragments, mostly granitic gneiss gravel; medium acid; abrupt, smooth boundary. 6 to 9 inches thick.

B1—7 to 13 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam; moderate, medium, granular and weak, medium, subangular blocky structure; friable; many roots; 20 percent coarse fragments, mostly granitic gneiss gravel; very strongly acid; gradual, wavy boundary. 0 to 9 inches thick.

B21—13 to 21 inches, strong-brown (7.5YR 5/6) gravelly sandy loam; weak, coarse, granular and weak, fine, subangular blocky structure; friable; many roots; sand grains and gravel distinctly coated or stained, but no bridges between grains; 20 percent coarse fragments; very strongly acid; gradual, wavy boundary. 0 to 12 inches thick.

B22—21 to 30 inches, strong-brown (7.5YR 5/6) gravelly sandy loam; moderate, medium, subangular blocky structure; friable; many roots; sand grains and gravel coated or stained and some clay bridges between sand grains; 20 percent coarse fragments, a few stones, common cobbles; very strongly acid; gradual, wavy boundary. 6 to 20 inches thick.

B3—30 to 41 inches, yellowish-brown (10YR 5/6) sandy loam; weak, medium, subangular blocky structure; friable; few roots; sand grains and gravel stained or coated, but bridges or clay films in only a few isolated areas; 10 percent coarse fragments; very strongly acid; gradual, wavy, boundary. 0 to 18 inches thick.

C—41 to 60 inches, light yellowish-brown (10YR 6/4 and 2.5Y 6/4) sandy loam; massive; slightly firm; very few roots; sand grains lightly stained, but base color of the grains show through; 10 percent coarse fragments; strongly acid.

The solum ranges from 30 to 50 inches in thickness. Coarse fragments range from 10 to 50 percent throughout the profile. The fragments are a mixture of rounded to subangular gravel, cobbles, stones, and boulders in various proportions. They are mostly granitic gneiss and a small amount of shale, sandstone, quartzite, or conglomerate. In areas that are not limed, reaction ranges from strongly acid to very strongly acid throughout.

The Ap and A1 horizons range from very dark grayish brown (10YR 3/2) to brown (7.5YR 5/4). Where these horizons have both value and chroma of less than 4, they are less than 10 inches thick. In unplowed areas there is a thin A2 or A3 horizon in which chroma is generally lower than in the underlying B horizon.

The B horizon ranges from yellowish brown (10YR 5/8) to brown (7.5YR 4/4). Typically, the upper part of the C horizon is light yellowish-brown or brownish-yellow, slightly weathered gravelly and cobbly sandy loam. The lower part of the C horizon is pale brown, brownish yellow, or olive yellow, and the material is relatively unweathered.

Netcong soils are associated with Parker, Edneyville, Bartley, Turbotville, Rockaway, and Hibernia soils. They contain fewer coarse fragments than Parker soils. They have less clay in the B horizon than Edneyville soils. Netcong

soils do not have the fragipan that is common in Bartley, Turbotville, Rockaway, and Hibernia soils.

Netcong gravelly sandy loam, 3 to 8 percent slopes (NtB).—This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of more sloping Netcong soils and soils that are similar to this Netcong soil, but the combined thickness of the surface layer and subsoil is less than 30 inches. Also included are small wet spots or swales and areas of very gravelly, cobbly, or stony soils.

This soil is well suited to general farming and to most specialty crops grown in the county. It has a slight hazard of erosion. Suitable erosion control practices are contour cultivation and stripcropping on long slopes. Deep-rooted, drought-resistant crops, such as alfalfa, Ladino clover, orchardgrass, and bromegrass, are suitable. High-value crops need irrigation. Capability unit IIe-7.

Netcong gravelly sandy loam, 8 to 15 percent slopes (NtC).—Included with this soil in mapping are small areas of more gently sloping or steeper Netcong soils and areas of Parker, Edneyville, and Rockaway soils. Also included are small wet areas; small areas of soils that are similar to this Netcong soil, but the combined thickness of the surface layer and subsoil is less than 30 inches; and areas of very gravelly, cobbly, or stony soils.

This soil is suited to most general crops and to most specialty crops grown in the county. It has a moderately severe hazard of erosion. Suitable erosion control practices are cultivating and stripcropping on the contour and constructing diversions on long slopes. For community development, the soil has limitations because of complex slopes. Stabilization of steep road cuts and other similar steep banks is a major concern of management. Capability unit IIIe-7.

Otisville Series

The Otisville series consists of deep, gently sloping to steep, excessively drained soils. These soils are on gently rolling high terraces or steep-sided kames within the valleys of the northern highlands. They formed in assorted gravelly and sandy glacial outwash deposits that have a high proportion of granitic gneiss coarse fragments. The glacial deposits are loose, stratified sand and gravel many feet thick.

In representative profile the surface layer is very dark grayish-brown gravelly loamy sand about 8 inches thick. The subsoil is brown gravelly loamy sand 6 inches thick. The substratum to a depth of 60 inches is light brownish-gray and very pale brown, loose very gravelly sand.

Permeability is rapid, and the available water capacity is low. These soils have very good workability, stability, and compaction characteristics. They are only slightly compressible and have low subsidence.

Droughtiness, the hazard of erosion, and low fertility limit the range of crops that can be grown on these soils. The native vegetation is hardwood trees, mainly oak. Most areas are woodland. Most areas that were formerly cleared for farming are now reverting to woodland. Gray birch predominates. Otisville soils are a potential source of sand and gravel for road fill, asphalt, and concrete aggregate.

Representative profile of Otisville gravelly loamy sand, 3 to 15 percent slopes, on the edge of a borrow pit 40 yards east of Rockaway Valley Road, 0.2 of a mile north of the junction with Valley Road, in Boonton Township:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) gravelly loamy sand; weak, fine, granular structure; very friable; many, fine, fibrous roots; 40 percent rounded gravel and rounded cobbles, mostly granitic gneiss and a small quantity of fragments of other kinds of rock; very strongly acid; clear, wavy boundary. 3 to 8 inches thick.

B2—8 to 14 inches, brown (7.5YR 4/4) gravelly loamy sand; single grained; loose; many, fine, fibrous roots; 40 percent well-graded rounded gravel and cobbles; strongly acid; abrupt, wavy boundary. 10 to 16 inches thick.

C1—14 to 25 inches, light brownish-gray (10YR 6/2) and very pale brown (10YR 7/3) very gravelly sand; single grained; loose; common, fine, fibrous roots; 50 percent well-graded rounded gravel and 5 percent cobbles; medium acid; gradual, wavy boundary. 0 to 20 inches thick.

C2—25 to 60 inches, very pale brown (10YR 7/3) very gravelly sand of light-colored and dark-colored individual grains; single grained; loose; 50 percent well-graded rounded gravel and 5 percent cobbles; medium acid.

The solum ranges from 14 to 24 inches in thickness; the lower part of the solum is generally marked by a fading from darker color to lighter color. In some places, however, the lower boundary of the solum is indistinct because of a very gradual fading in color. Generally, the solum has hue of 7.5 YR and the substratum has hue of 10YR, but in some places the solum has hue of 10YR. Coarse fragments make up 35 to 50 percent of the A and B horizons and 35 to 70 of the C horizon. A few profiles are cobbly, and some have stones or boulders. The coarse fragments and the sand grains are derived mostly from granitic gneiss, but a small quantity of other material, such as red and gray shale, conglomerate, and quartzite, is also present. In areas that are not limed, reaction ranges from medium acid to very strongly acid throughout.

In unplowed areas the A1 horizon ranges from 2 to 3 inches in thickness and in places is underlain by a 2- or 3-inch-thick sequence of grayish A2 and brownish B2 material, which in plowed areas has been mixed into the plow layer.

The B horizon ranges from dark-brown to strong-brown gravelly sandy loam to gravelly loamy sand.

The underlying material is light brownish-gray to very pale brown gravelly loamy sand to gravelly sand and their very gravelly analogs.

Otisville soils are associated with Riverhead, Pompton, and Rockaway soils. They contain less clay than those soils.

Otisville gravelly loamy sand, 3 to 15 percent slopes (OtC).—This soil has the profile described as representative of the series. Included in mapping are small areas of more strongly sloping Otisville, Riverhead, and Pompton soils.

This gently sloping to strongly sloping soil has moderate or moderately rapid runoff, rapid permeability, and low available water capacity. It is slightly erodible.

A high content of coarse fragments, low available water capacity, and low fertility reduce the suitability of this soil for crops. Capability unit VIIs-12.

Otisville gravelly loamy sand, 15 to 25 percent slopes (OtD).—This soil has a profile similar to the one described as representative of the series, but coarse fragments are more abundant. Slopes are complex.

This steep gravelly and cobbly soil has rapid permeability, low available water capacity, and a moderate hazard of erosion.

This soil is not suited to row crops, which can be grown year after year. In cultivated areas, careful management and conservation practices are needed to conserve water and to help to control erosion. Among the suitable practices are contour cultivation, stripcropping, and growing cover crops. Steepness is a limitation to many community developments. Capability unit VIIs-12.

Parker Series

The Parker series consists of deep, gently sloping to very steep, excessively drained soils that contain a large amount of angular granitic stones, cobbles, and gravel. The more gently sloping soils are on irregularly shaped ridgetops, and the steeper soils are in elongated areas on the sides of ridges.

In a representative profile in a wooded area, about 3 inches of partly decomposed leaves and twigs overlies about 7 inches of black humus that is mixed with gravel, cobbles, and stones. The humus overlies the mineral surface layer, which is dark-brown very gravelly sandy loam about 5 inches thick. The upper 15 inches of the subsoil is brown very gravelly loam, and the lower 11 inches is dark yellowish-brown very gravelly sandy loam. The substratum to a depth of 60 inches is yellowish-brown sandy loam that is 60 percent coarse fragments.

Permeability is moderately rapid. Available water capacity is low because of the high content of coarse fragments. Parker soils are difficult to work because coarse fragments are abundant.

Removal of the stones is necessary if cultivated crops are grown. Stones have been removed from most farmed areas. Most Parker soils are woodland.

Representative profile of Parker very gravelly sandy loam in an area of Parker-Edneyville extremely stony sandy loams, 15 to 25 percent slopes, in a wooded area near base of steeper slopes, 870 feet north of Hanover Avenue across Hanover Avenue from junction with Raynor Road:

O1—10 to 7 inches, leaves and twigs of oak, yellow-poplar, and ash. 0 to 8 inches thick.

O2—7 inches to 0, black (10YR 2/1) partly decomposed organic matter between angular stones, gravel, and cobbles; strongly acid. 2 to 7 inches thick.

A1—0 to 5 inches, dark-brown (7.5YR 3/2) very gravelly sandy loam; strong, coarse, granular structure; friable; many fine roots and few large roots; 50 percent angular stones, cobbles, and gravel; strongly acid; abrupt, irregular boundary. 2 to 8 inches thick.

B21—5 to 20 inches, brown (7.5YR 4/4) very gravelly loam; moderate, coarse, granular structure; very friable; few fine roots and many large roots; 50 percent angular gravel, cobbles, and stones; strongly acid; diffuse, irregular boundary. 5 to 20 inches thick.

B22—20 to 31 inches, dark yellowish-brown (10YR 4/4) very gravelly sandy loam; moderate, coarse, granular structure and moderate, fine, subangular blocky; very friable; few fine and large roots; 50 percent angular stones, cobbles, and gravel; very strongly acid; diffuse, irregular boundary. 0 to 20 inches thick.

C—31 to 60 inches, yellowish-brown (10YR 5/4) sandy loam; weak, coarse, granular structure; very friable; few fine roots; 60 percent angular stones, cobbles, and gravel, mostly hard and unweathered; very strongly acid.

Depth to bedrock is commonly 4 feet but in some places it is 10 feet or more. The solum ranges from 20 to 40 inches in thickness and averages about 30 inches. The content of coarse fragments ranges from 35 to 70 percent in the solum and from 60 to 90 percent in the substratum. Coarse fragments commonly range from gravel to stones in size, but in various places the profile is dominated by gravel, cobbles, or stones. Stones and cobbles have been removed from most fields. In areas that are not limed, reaction ranges from very strongly acid to strongly acid throughout.

The A horizon ranges from very dark gray (10YR 3/1) to brown (7.5YR 4/4) sandy loam, gravelly sandy loam, very gravelly loam, and very gravelly loam that is extremely stony in places.

The B horizon ranges from dark-brown (10YR 4/3) to reddish-yellow (7.5YR 6/6) sandy loam, loam, and their gravelly or cobbly analogs.

The C horizon ranges from brown (10YR 5/3) to strong brown (7.5YR 5/6). Color patterns are apparently caused by differential weathering of the banded gneiss or related kinds of bedrock.

In most places the bedrock is granitic gneiss.

Parker soils are near Edneyville, Annandale, and Califon variant soils. They have a higher content of coarse fragments and a lower content of clay in the B horizon than Edneyville and Annandale soils. They do not have the mottles that are common in the Califon variant.

Parker gravelly sandy loam, 3 to 15 percent slopes (PaC).—This soil has a profile similar to the one described as representative of the series, but it contains fewer stones. Depth to bedrock is 6 to 10 feet or more.

Included with this soil in mapping are small areas of Edneyville, Annandale, and Califon soils; the Califon friable subsoil variant; and very stony and steeper Parker soils.

If the stones are removed, this soil is suited to hay and pasture. If the soil is used for corn, small grain, or other cultivated crops, practices to help control erosion and removal of stones and cobbles are needed. This soil is limited for community development because of coarse fragments, shallowness to bedrock, low available water capacity, and the hazard of erosion. Capability unit IIIe-58.

Parker very gravelly sandy loam, 15 to 25 percent slopes (PbD).—This soil has a profile similar to the one described as representative of the series, but it contains fewer stones, and the surface layer is more than 50 percent gravel. The subsoil is as much as 40 percent angular granitic gneiss gravel and 30 percent cobbles and stones. Depth to bedrock is generally 4 to 6 feet.

Included with this soil in mapping are small areas of Edneyville and Parker soils and the Califon friable subsoil variant.

This soil is poorly suited to cultivated crops because of steepness, the high content of coarse fragments in the subsoil, rapid runoff, low available water capacity, and the severe hazard of erosion. This soil is suited to hay and pasture. It is limited for community development because of steepness, the high content of coarse fragments, low available water capacity, and shallowness to bedrock. Capability unit VIs-58.

Parker-Edneyville extremely stony sandy loams, 3 to 15 percent slopes (PeC).—This complex is 50 to 75 percent Parker soils and 25 to 50 percent Edneyville soils. These soils contain 2 to 5 percent boulders, 5 to 10 percent stones, 10 to 20 percent cobbles, and 10 to 30 percent gravel. Bedrock is generally at a depth of 6 to 10 feet or more. Available water capacity is low.

Included with this complex in mapping are areas of Califon soils and the Califon friable subsoil variant. Also included are areas of steeper or less stony Edneyville soils. Rock outcrop makes up less than 10 percent of each area mapped.

The high content of boulders, stones, cobbles, and rock outcrop makes crop production impractical. This complex is limited for community development, mainly because of coarse fragments and slope (fig. 9). If this complex is used for residential developments, the hazard of erosion during construction is moderate. Capability unit VIIs-22.

Parker-Edneyville extremely stony sandy loams, 15 to 25 percent slopes (PeD).—This complex is 60 to 80 percent Parker soils and 20 to 40 percent Edneyville soils. The Parker soils have the profile described as representative of the Parker series. The soils contain 2 to 5 percent boulders, 5 to 10 percent stones and cobbles, and 20 to 30 percent gravel. Bedrock is generally at a depth of 4 to 6 feet. Available water capacity is low.

Included with this complex in mapping are areas of Califon soils and the Califon friable subsoil variant. Also included are areas of less steep and less stony Parker and Edneyville soils. Areas of rock outcrops, which make up less than 10 percent of the mapped areas, are included.

Steepness, coarse fragments, and low available water capacity severely limit this complex for cultivated crops. Use of this complex is limited to pasture, woodland, and wildlife habitat. The complex is limited for community development by steepness, low available water capacity, coarse fragments, and rock outcrops (fig. 10). If this complex is used for residential developments, the hazard of erosion during construction and runoff after construction are concerns of management. Capability unit VIIs-22.

Parker-Rock outcrop complex, 20 to 35 percent slopes (PfE).—This complex is 65 to 90 percent Parker soils and 10 to 35 percent Rock outcrop. The Parker soils are extremely stony. Bedrock is generally at a depth of 4 to 6 feet.

Included with this complex in mapping are areas of Edneyville very stony sandy loam and steeper or less sloping Parker soils.

Because of steepness, rock outcrops, and the high content of stones, areas of this complex have not been cleared of trees and stones for farming. This complex is better suited to woodland than to most other uses. The dominant vegetation is oak and hickory trees. The complex is limited for community development, principally because of steepness, coarse fragments, rock outcrops, and a severe hazard of erosion. Control of erosion, runoff, and sedimentation is needed if this

Figure 9.—**Urban development on an area of Parker-Edneyville extremely stony sandy loams, 3 to 15 percent slopes. Large stones unearthed during construction, grading, and excavation are buried as a means of disposal.**

Figure 10.—**Homesite on Parker-Edneyville extremely stony sandy loams, 15 to 25 percent slopes. Builder has used natural steep slopes, Rock outcrop, and existing trees to advantage in landscaping.**

complex is used for residential development. If this complex is extensively excavated, large quantities of stones that are likely to be dug up present disposal problems. Capability unit VIIs-22.

Parsippany Series

The Parsippany series consists of deep, nearly level, poorly drained soils that have a moderately fine textured subsoil. These soils are on the nearly level bottom of the basin formerly occupied by glacial Lake Passaic. They formed in stratified sediment of lacustrine origin, derived mostly from red and brown shale, basalt, and granitic rock. Coarse fragments are very rare or are absent.

In a representative profile the surface layer is dark-gray silt loam about 7 inches thick. The upper part of the subsoil is grayish-brown silt loam about 7 inches thick, the middle is light brownish-gray clay loam about 6 inches thick, and the lower part is gray silty clay loam about 14 inches thick. The subsoil is mottled throughout with shades of brown and red. The substratum to a depth of 64 inches is reddish-brown, firm silty clay loam mottled with gray and brown.

Permeability is slow, and available water capacity is high. Because of the high content of silt and clay, the soils have poor workability, low stability, and poor compaction characteristics, especially when they are wet. The water table is perched at or near the surface during much of winter, early in spring, and after heavy rains. During summer it drops to a depth of 3 or 4 feet. After rains and early spring thaws, ponding is likely. Along major streams, such as the Passaic and Whippany Rivers and Black Brook in the eastern part of the county, stream flooding is likely late in winter, early in spring, and after heavy, long rains in summer.

The native vegetation is swamp maple, sweetgum, pin oak, elm, and many wetland bushes. Some large tracts have been cleared and at least partly drained. Such areas are used mainly for pasture and hay. If Parsippany soils are used for cultivated crops, improved drainage is necessary. Choice of crops and timing of farming practices are limited by excessive wetness. Because of slow permeability, low relief, and limited outlets, adequate drainage for farming and community development is difficult to achieve. Surface or open ditches are effective in improving drainage. In addition, flooding is a hazard in low-lying areas adjacent to streams. Most areas are woodland.

Representative profile of Parsippany silt loam, in a hayfield, 100 feet east of Pleasant Plains Road, 2,700 feet north of junction with White Bridge Road, in Harding Township:

Ap—0 to 7 inches, dark-gray (10YR 4/1) silt loam; moderate, very coarse, granular structure; very friable; many, fine, fibrous roots; most sand grains are stained a dark color by organic matter, but some

sand grains are clean and uncoated; strongly acid; abrupt, smooth boundary. 6 to 10 inches thick.

B1g—7 to 14 inches, grayish-brown (10YR 5/2) heavy silt loam; few, medium, distinct, strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/6) mottles; weak, coarse, subangular blocky structure; friable; common fine fibrous roots; 10 percent discontinuous, darker colored, waxy clay films on ped faces, many fine clean sand grains; strongly acid; clear, smooth boundary. 0 to 10 inches thick.

B21tg—14 to 20 inches, light brownish-gray (10YR 6/2) heavy clay loam; many, coarse, distinct, strong-brown (7.5YR 5/6) mottles and many, medium, prominent, yellowish-red (5YR 4/8) mottles; moderate, coarse, subangular blocky structure; friable, slightly plastic and slightly sticky when wet; common, fine, fibrous roots that decrease in number with increasing depth; thick waxy clay films on ped faces and some clay bridges; vertically oriented gray streaks or cracks are spaced 1 foot to 3 feet apart and have a glossy smooth surface; very strongly acid; clear, smooth boundary. 3 to 10 inches thick.

B22tg—20 to 34 inches, gray (5YR 5/1) heavy silty clay loam; many, coarse, distinct, yellowish-red (5YR 5/6) mottles and few, fine, faint, dark reddish-brown (5YR 3/2) mottles; moderate, coarse, subangular blocky structure; firm, plastic and sticky when wet; few, fine, fibrous roots; isolated patches of thick white or yellowish clay films on ped faces and some grayish vertically oriented streaks; medium acid; clear, smooth boundary. 10 to 20 inches thick.

C—34 to 64 inches, reddish-brown (5YR 5/4) light silty clay loam; many, coarse, distinct, gray (5GY 6/1) and brown (7.5YR 5/2) mottles; lower part has 1- to 3-inch strata of silt loam or sandy loam; moderate, medium and thick, platy structure; firm, slightly plastic and sticky when wet; few, fine, fibrous roots; slightly acid.

The solum is commonly about 36 inches thick but ranges from 30 to 50 inches. Depth to bedrock is more than 10 feet. Coarse fragments are generally lacking, but in places they make up a very small percentage of any horizon and 15 to 20 percent of the sandy layers in the C horizon below a depth of 40 inches. In areas that are not limed, reaction ranges from very strongly acid to slightly acid in the upper part of the solum and from slightly acid to slightly alkaline in the C horizon.,

The A horizon commonly has hue of 7.5YR or 10YR, value of 2 to 4, and chroma of 1 or 2.

The B horizon has matrix hue of 5YR to 10YR, value of 5 or 6, and chroma of 1 or 2. This horizon ranges from heavy silt loam to clay. Clay films are in the B horizon in all places, but they range from thick, well defined, nearly continuous to thin discontinuous. In some places there are pressure faces and slickensides.

The C horizon is 5YR to 7.5YR in hue, 4 to 6 in value, and 3 to 6 in chroma. The dominant texture above a depth of 40 inches ranges from heavy silty clay loam to clay, and in some places there are thin loamy strata or varves. Below a depth of 40 inches the C horizon typically consists of loamy strata that contain a high proportion of fine sand and silt and in places clayey strata or varves.

Parsippany soils are associated with Whippany, Preakness, and Pompton soils. They do not have the high-chroma matrix color in the B horizon that is common in Whippany soils. They contain more clay than Preakness and Pompton soils.

Parsippany silt loam (Ph).—This soil has the profile described as representative of the series. Included in mapping are small areas of Whippany and Pompton soils.

This nearly level soil has a perched water table at or near the surface for long periods. Permeability and runoff are slow. Because of its low position on the landscape, the soil receives runoff from adjoining higher areas.

This soil requires improved drainage if it is used for cultivated crops or for community development. In places where there is sufficient relief to provide outlets, surface drains and ditches are effective. Because of the continuing hazard of flooding, this soil has limitations for farming and community development. It is a natural site for dug ponds. Capability unit IVw-80.

Parsippany silt loam, sandy loam substratum (Pk).—This soil has a profile similar to the one described as representative of the series, but it has a thin substratum of fine sandy loam within 40 inches of the surface and is dominantly fine sandy loam or silt loam below a depth of 40 inches.

Included with this soil in mapping are areas of Whippany and Pompton soils that are too small to be mapped separately.

This nearly level soil has slow permeability in the subsoil and moderate permeability in the substratum. The water table is at or near the surface for long periods, and runoff is slow. The soil is in a low position on the landscape, and it receives runoff from adjoining higher areas.

This soil needs improved drainage if it is used for cultivated crops or for community development. Suitable drainage practices include digging deep ditches for peripheral drainage and shallow ditches along with bedding systems. Subsurface tile drainage is effective, but special precautions must be taken to provide adequate filtration around the tile to prevent the fine sandy loam substratum material from moving into and plugging the tile. The low position of this soil and the lack of sufficient grade for outlets of drainage systems are other limitations. This soil is a natural site for dug ponds. Capability unit IVw-81.

Pattenburg Series

The Pattenburg series consists of deep, gently sloping to strongly sloping, well-drained gravelly soils on rolling hilltops. These soils formed in material weathered from the underlying red conglomerate bedrock.

In a representative profile the surface layer is dark reddish-brown gravelly loam about 10 inches thick. The subsoil is reddish-brown gravelly loam about 24 inches thick. The substratum to a depth of 60 inches is reddish-brown very gravelly sandy loam that becomes progressively less weathered and more like bedrock with increasing depth.

Permeability is moderate in the surface layer and in the subsoil and rapid in the substratum. Runoff is moderate or rapid, and available water capacity is moderate. In most places the bedrock is deeply weathered and can be easily excavated by heavy equipment for use as borrow material or gravelly fill.

Most areas of Pattenburg soils are wooded or idle and are covered with brush. Locally, areas of gently sloping Pattenburg soils are cleared and used for cultivated crops, hay, and pasture. Common trees are red, black, chestnut, and white oaks and some beech, ash, yellow-poplar, and black birch.

Representative profile of Pattenburg gravelly loam, 3 to 8 percent slopes, 100 feet west of U.S. Highway No. 206, 20 feet south of private lane, one-half mile north of Somerset County line:

Ap—0 to 10 inches, dark reddish-brown (5YR 3/2) gravelly loam; moderate, medium, granular structure; very friable; many roots; 20 percent coarse fragments, mainly quartzose gravel and cobbles but containing a variety of other rock fragments, particularly shale or sandstone chips; strongly acid; clear, smooth boundary. 6 to 10 inches thick.

B2t—10 to 34 inches, reddish-brown (5YR 4/4) heavy gravelly loam; weak, fine, subangular block structure; friable, slightly sticky; common roots decreasing with increasing depth; 30 percent quartzose gravel and cobbles in the upper part ranging to 40 percent in the lower part, increasing amounts of bedrock chips in lower part; patchy clay films on ped faces and rare clay bridges; strongly acid; diffuse, wavy boundary. 15 to 30 inches thick.

C—34 to 60 inches, reddish-brown (2.5YR 4/4) very gravelly sandy loam; single grained; very friable; few roots; this horizon is transitional to bedrock; strongly acid.

The solum ranges from 24 to 36 inches in thickness, and depth to bedrock ranges from 3½ to 10 feet or more. Coarse fragments make up 20 to 40 percent of the solum and as much as 60 percent of the C horizon. The fragments are mostly rounded pebbles and a few cobbles. They are largely quartzite and quartzose shale and sandstone, but a small proportion consists of fragments of various other kinds of rock, such as granitic or micaceous gneiss. In many places the lower part of the solum has a high proportion of subangular chips or pieces of conglomerate bedrock. In areas that are not limed, reaction ranges from medium acid to strongly acid in the A and B horizons and from strongly acid to very strongly acid in the C horizon.

The Ap horizon has hue of 2.5YR or 5YR, value of 3 or 4, and chroma of 2 or 3.

The B horizon is 5YR to 10R in hue, 3 or 4 in value, and 4 to 6 in chroma. This horizon is commonly heavy gravelly loam but ranges to gravelly silt loam and in a few places gravelly clay loam.

The C horizon commonly is 10R or 2.5YR in hue but ranges to 5YR, 3 or 4 in value, and almost always 4 in chroma. This horizon is gravelly sandy loam, gravelly loam, and their very gravelly analogs.

Bedrock is soft sandy shale conglomerate.

Pattenburg soils are associated with Penn, Klinesville, Edneyville, Bartley, and Rockaway soils. They are similar to Penn and Klinesville soils in color but are deeper than both. Pattenburg soils are redder and contain more gravel than Edneyville and Bartley soils. They do not have a fragipan that is common in Bartley and Rockaway soils.

Pattenburg gravelly loam, 3 to 8 percent slopes (PlB).—This soil has the profile described as representative of the series. Included in mapping are small areas of Penn and Bartley soils and soils that are similar to this Pattenburg soil, but they have a surface layer of gravelly sandy loam.

This soil is well suited to farming and community development. The principal limiting properties are the relatively high proportion of coarse fragments and moderate erodibility. Adequate control of erosion can be easily achieved on farmland by use of contour cultivation, a crop rotation, cover crops, and stripcropping on long slopes. Irrigation is generally used for high-value crops. Capability unit IIe-58.

Pattenburg gravelly loam, 8 to 15 percent slopes (PlC).—This soil has a profile similar to the one described as representative of the series, but the surface layer contains slightly more gravel. Included in mapping are small areas of soils that are similar to the Pattenburg soil, but they have a surface layer of gravelly sandy loam or loam. Also included are areas of Penn and Klinesville soils. These soils are not so deep over bedrock as Pattenburg soils.

This soil is well suited to pasture and hay. It can be cultivated year after year, but because it is strongly sloping, the hazard of erosion is moderately high. Other properties that limit the use of this soil are the relatively high proportion of coarse fragments, rapid runoff, and moderate available water capacity. Adequate control of erosion can be achieved on farmed areas through the use of contour cultivation, a crop rotation, stripcropping, and diversions. If this soil is used for community developments, the hazard of erosion is likely to be severe on steep slopes. Capability unit IIIe-58.

Penn Series

The Penn series consists of moderately deep, gently sloping to steep, well-drained shaly soils. These soils are on hillsides within the Passaic basin and in the valleys of the North Branch Raritan River and Gladstone Brook.

In a representative profile the surface layer is dark-brown shaly silt loam about 8 inches thick. The subsoil is reddish-brown shaly silt loam about 22 inches thick. The substratum is reddish-brown very shaly silt loam. Bedded shale and siltstone are at a depth of 36 inches.

Permeability is moderately slow or moderate, and available water capacity is moderate. Because of their high content of silt, these soils have poor stability and compaction characteristics, especially when they are wet or very dry. Penetration of roots is restricted by bedrock at a moderate depth.

Penn soils support stands of oak and hickory trees. The areas have been cleared and used for dairy farming, general farming, and, to a lesser extent, vegetable crops. The hazard of erosion, moderate available water capacity, and moderate depth to bedrock limit the kinds of crops that can be grown.

Representative profile of Penn shaly silt loam, 8 to 15 percent slopes, one-fourth mile northeast of junction of East Fox Chase Road and Roxiticus Road, 2,000 feet north of Roxiticus, 1,100 feet east of lane along the edge of the woodlot:

Ap—0 to 8 inches, dark-brown (7.5YR 4/2) shaly silt loam; moderate, medium, granular structure; very friable, nonsticky, nonplastic; few quartzose pebbles scattered on the surface; 20 percent shale chips; dark stains on coatings on most sand grains and on all peds; slightly acid; clear, wavy boundary. 7 to 9 inches thick.

B1—8 to 14 inches, reddish-brown (5YR 4/4) shaly silt loam that contains more clay than Ap horizon; moderate, fine to medium, subangular blocky structure; friable, nonplastic, nonstocky; common, fine, fibrous roots; 20 percent shale chips; stains or coatings on most sand grains; slightly acid; diffuse, wavy boundary. 0 to 6 inches thick.

B2t—14 to 24 inches, reddish-brown (5YR 4/4) shaly heavy silt loam; moderate, coarse, subangular blocky structure; friable, slightly sticky, slightly plastic; common, fine fibrous roots; 25 percent shale chips from 2 millimeters to 3 centimeters long; discon-

tinuous slightly glossy clay films on ped faces, and sand grains are bridged; slightly acid; diffuse, wavy boundary. 10 to 20 inches thick.

B3—24 to 30 inches, reddish-brown (5YR 4/4) shaly silt loam; weak, medium, subangular blocky structure; friable; few fine roots; few glossy, thick clay films on peds, in voids, and on shale chips; 35 percent shale chips that range in size from 2 millimeters to 5 centimeters in diameter and are less than 3 centimeters thick; medium acid; diffuse, irregular boundary. 0 to 10 inches thick.

C—30 to 36 inches, reddish-brown (5YR 4/4) very shaly silt loam; massive; firm to friable; 50 percent shale chips, mostly with glossy coatings or weathering rinds; strongly acid; diffuse, irregular boundary. 0 to 10 inches thick.

R—36 inches, reddish-brown (5YR 4/4), interbedded, weathered, fractured shale and siltstone.

The solum ranges from 20 to 36 inches in thickness. Depth to bedrock is 20 to 40 inches. Angular fragments or chips of red shale, siltstone, or sandstone occur throughout the profile. They make up 15 to 30 percent of the A horizon, 20 to 35 percent of the B horizon, and 30 to more than 50 percent of the C horizon. In areas that are not limed, reaction ranges from extremely acid to strongly acid in the upper part of the solum and strongly acid or slightly acid in the C horizon.

The A horizon is 5YR to 7.5YR in hue, 3 to 4 in value, and 2 or 3 in chroma.

The B horizon is 5YR to 2.5YR in hue, 3 or 4 in value, and 4 in chroma. This horizon is shaly silt loam or shaly loam.

The C horizon is lacking in some places. In such places, a B3 or B2t horizon rests directly on the weathered bedrock.

Penn soils are associated with Edneyville, Bartley, Pattenburg, Neshaminy, Reaville variant, Whippany, and Pompton soils. Penn soils are not so deep as Edneyville, Bartley, Pattenburg, Neshaminy, Whippany, and Pompton soils. They do not have the mottles that are common in the Reaville deep variant.

Penn shaly silt loam, 3 to 8 percent slopes (PnB).—This soil has a profile similar to the one described as representative of the series, but the content of shale fragments is slightly lower. Included in mapping are areas of more strongly sloping Penn soils and the Reaville deep variant.

Runoff, the hazard of erosion, and depth to fractured bedrock are moderate.

In addition to good management, this soil requires easily applied practices to help control runoff and erosion. In farmed areas, suitable practices that reduce erosion include the use of cover and sod crops, contour cultivation, and stripcropping on long slopes. Capability unit IIe-65.

Penn shaly silt loam, 8 to 15 percent slopes (PnC).—This soil has the profile described as representative of the series. Included in mapping are small areas of Klinesville soils, more gently sloping Penn soils, and Pattenburg soils.

Runoff is moderately rapid, and the hazard of erosion is moderately severe.

In addition to good management, this soil requires complex conservation practices to help control runoff and erosion. In farmed areas, contour stripcropping, diversions, and the use of sod or close-growing crops are effective. If this soil is used for suburban developments, use of a temporary grass cover to protect cleared areas prior to grading and landscaping, early establishment of lawns and landscaped areas, division of long slopes by use of diversions or streets, and use of temporary or permanent desilting basins reduce damage caused by sedimentation. Capability unit IIIe-65.

Penn-Klinesville shaly silt loams, 15 to 25 percent slopes (PoD).—This complex is about 60 percent Penn soils and 40 percent Klinesville soils. The soils occur in complex patterns, and they cannot be mapped separately. In addition, the differences between the soils are less significant on these steep slopes. The Penn soils are largely shaly, and depth to bedrock is in the shallower range of the Penn series. Included in mapping are areas of deep and less shaly soils and a few small isolated areas of Rock outcrop.

The high proportion of coarse fragments throughout the soil, very rapid runoff, shallow or moderate depth over fractured shale bedrock, moderate or low available water capacity, and a severe hazard of erosion severely restrict the use of this complex. This complex is better suited to hay or pasture than to other uses. It has severe limitations for community development. Capability unit VIe-65.

Pits, Sand and Gravel

Pits, sand and gravel (Ps) consists of open excavations and adjoining areas of fill material removed during the mining of sand, gravel, and borrow material. This land type includes both active and abandoned pits. Sand and gravel pits are the most extensive and are commonly in areas of glacial outwash, the material in which Riverhead and Otisville soils formed. Some pits are in areas of stony and cobbly glacial till. Most of the pits are on uplands and are 6 to 20 feet deep. In the vicinity of Succasunna and Pompton Plains, the sand and gravel strata are in a low position on the landscape and extend below the water table. In these areas dredging has been used to mine the sand and gravel, and large ponds have been created in the process. Some of these ponds have been converted to use for swimming, fishing, or skating.

Most abandoned pits have steep to vertical sides. Rehabilitation of sand and gravel pits is generally difficult because fertility is low and the material is erodible. Not assigned to a capability unit.

Pompton Series

The Pompton series consists of deep, nearly level to gently sloping, somewhat poorly drained soils. These soils are on terraces and outwash plains in the major valleys of the northern half of Morris County and in gently sloping waterways or swales that cross the terraces and extend into the uplands. They formed in sandy and gravelly glacial outwash derived mainly from granitic material and in places from red and brown shale and traprock and a small amount of other kinds of material, such as quartzite, sandstone, and conglomerate. The soils are underlain by stratified, water-sorted sand and gravel.

In a representative profile the surface layer is very dark grayish-brown sandy loam about 7 inches thick. The upper part of the subsoil, to a depth of about 28 inches, is yellowish-brown sandy loam mottled with yellow, light brownish gray, and strong brown. Below

this, and extending to a depth of about 36 inches, the subsoil is yellowish-brown gravelly sandy loam mottled with light brownish gray. The substratum is yellowish-brown and light olive-brown, loose gravelly loamy sand to a depth of 60 inches.

Permeability is moderately rapid, and available water capacity is moderate. These soils have a seasonal water table at a depth of ½ foot to 1½ feet in winter and in spring. Generally, they are not subject to flooding, but the soils in nearly level areas or in depressions are ponded for several days after heavy rains or fast thaws, especially late in winter. They are easily drained by open ditches or underdrains. In places some areas near the base of the steeper slopes need surface drainage. The organic-matter content is moderate in the surface layer.

Drained areas of Pompton soils are suited to general crops and pasture. Unless limed, the soils are strongly acid to very strongly acid throughout. The native vegetation is hardwoods, mostly red, white, and black oaks; maple; beech; and hickory. About 80 percent of the acreage was formerly cleared and used for crops. Most of these areas are now idle and are reverting to woodland. If high-value crops are grown, intensive drainage is required. In places, if these soils are used for some community developments, spot drainage and erosion control measures are needed.

Representative profile of Pompton sandy loam, 3 to 8 percent slopes, at the edge of a field one-half mile southwest of Route 10, one-fourth mile southeast of railroad tracks, at the southwestern edge of the community of Succasunna:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) sandy loam; moderate, medium, crumb structure; friable; most sand grains and pebbles are clean and uncoated, but some are stained with dark-colored organic matter; 5 percent gravel; medium acid; abrupt, smooth boundary. 3 to 8 inches thick.

B1—7 to 10 inches, yellowish-brown (10YR 5/4) sandy loam; few, fine, faint, yellow (2.5Y 7/8) and light brownish-gray (2.5Y 6/2) mottles; weak, medium, subangular blocky structure; friable; 10 percent gravel; strongly acid; clear, wavy boundary. 0 to 3 inches thick.

B2—10 to 28 inches, yellowish-brown (10YR 5/4) sandy loam; common, medium, distinct, light brownish-gray (2.5Y 6/2) mottles and common, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, medium, subangular blocky structure; friable, slightly sticky when wet; ped faces are slightly darker than interiors; 10 percent gravel; strongly acid; gradual, wavy boundary. 12 to 30 inches thick.

B3—28 to 36 inches, yellowish-brown (10YR 5/4) gravelly sandy loam; common, medium, distinct, light brownish-gray (2.5Y 6/2) mottles; massive; firm to friable; 20 percent rounded gravel and rare cobbles, mostly granitic but a few sandstone, shale, and quartzite; strongly acid; clear, wavy boundary. 0 to 12 inches thick.

IIC—36 to 60 inches, yellowish-brown (10YR 5/6) and light olive-brown (2.5Y 5/6) gravelly loamy sand that has some nearly black spots; single grained; most sand grains are clean and uncoated, some feldspar grains show weathering surfaces, many dark ferromagnesian grains and some white feldspar and quartz grains; 20 percent rounded gravel, 2 percent cobbles, mostly granitic; strongly acid.

The solum ranges from 26 to 36 inches in thickness but is commonly about 30 inches. Depth to bedrock is 10 feet or more. Coarse fragments make up 5 to 30 percent of the A and B horizons and 5 to 50 percent of the IIC horizon. The coarse fragments are generally the size of pebbles and cobbles. They are almost all rounded and mainly granitic material but include various fragments of other kinds of rock except limestone. In the eastern part of Morris County the soils also contain a high proportion of traprock and red shale. These soils have a slightly larger proportion of medium and fine sand and are likely to have pockets, lenses, or layers of silty or very fine sandy material in the C horizon.

In unplowed areas a very dark gray A1 horizon is 1 to 4 inches thick. The Ap horizon is 10YR to 7.5YR in hue, 3 or 4 in value, and 2 or 3 in chroma.

The B horizon has a matrix color of 10YR to 7.5YR in hue, 4 or 5 in value, and 4 to 6 in chroma. Light brownish-gray to dark grayish-brown mottles are at a depth of 6 to 18 inches, and yellowish-brown to yellowish-red mottles occur throughout the B horizon.

The C horizon consists of stratified loamy sand and gravelly loamy sand. This horizon is 10YR to 2.5YR in hue, 5 to 7 in value, and 2 to 8 in chroma.

Pompton soils are associated with Riverhead, Otisville, Hibernia, and Preakness soils. They have low-chroma mottles, which Riverhead and Otisville soils lack. They do not have a fragipan, which is common in Hibernia soils. They do not have the low-chroma matrix colors that are common in Preakness soils.

Pompton sandy loam, 0 to 3 percent slopes (PtA).—This soil is in wide, nearly level swales on terraces and on broad, low outwash plains. Included in mapping are small areas of Pompton gravelly sandy loam, Preakness and Riverhead soils, and a soil that is similar to this Riverhead soil, but it is reddish.

This soil is suited to hay and pasture, and drained areas are suited to most cultivated crops. Large areas near Pequannock have been used for vegetable and other specialized crops. Underdrains or deep open ditches are used to improve drainage. Most of the acreage is used for residential developments. A moderately high seasonal water table, ponding for long periods after heavy rains, and infrequent flooding are the main limitations for community development. Capability unit IIw-25.

Pompton sandy loam, 3 to 8 percent slopes (PtB).—This soil has the profile described as representative of the series. It is in swales and waterways in relatively low positions and receives runoff from the surrounding uplands. This soil frequently receives runoff more rapidly than it can be drained, and the water table fluctuates.

This soil is used for pasture, hay, and cultivated crops. Suitable conservation practices include constructing interceptor drains and diversions and establishing a sod cover to reduce erosion. The fluctuating water table and the hazard of erosion are the main limitations for community development. Capability unit IIw-25.

Preakness Series

The Preakness series consists of deep, nearly level, poorly drained soils. These soils are mostly on the broad outwash plain in the vicinity of Pequannock, extending to the south into the basin of extinct glacial Lake Passaic and on the outwash plain extending to the south of Succasunna. They are also in isolated depressions in the narrow waterways or swales that dissect outwash terraces in the narrow valleys of the northern part of the county. The soils are mostly granitic material, but they contain a small quantity of

other kinds of minerals, such as quartzite, sandstone, and shale.

In a representative profile the surface layer is very dark gray sandy loam about 8 inches thick. The subsurface layer is very dark gray, mottled sandy loam about 4 inches thick. Between depths of 12 and 30 inches is the grayish-brown, mottled sandy loam subsoil. The substratum is stratified grayish-brown gravelly loamy sand and gravelly sandy loam to a depth of 60 inches.

Permeability is moderately rapid, and available water capacity is moderate. The water table is at or near the surface late in fall, in winter, and in spring. In many places these soils are ponded in winter, and they are subject to annual floods in spring and low-frequency floods in summer. They are underlain by stratified, water-sorted deposits of sand and gravel. They are frequently too wet to support heavy equipment needed in obtaining road fill, but they are a source of sand and gravel. Because of the high water table, a dredge type of operation is generally required for mining sand and gravel.

The native vegetation is wetland plants. Drained areas of Preakness soils are suited to intensive cultivation for vegetable and specialty crops. Because of the low position, high water table, and low relief of the soils, outlets for drainage systems are frequently difficult to locate. Most areas are woodland.

Representative profile of Preakness sandy loam, 0 to 4 percent slopes, one-fourth mile east of Comly Road, north side of Interstate Highway No. 287:

Ap—0 to 8 inches, very dark gray (10YR 3/1) sandy loam, gray (10YR 5/1) when dry; moderate, medium, granular structure; friable; less than 5 percent fine gravel; slightly acid; clear, smooth boundary. 6 to 10 inches thick.

A12—8 to 12 inches, very dark gray (N 3/0) sandy loam, gray (N 5/0) when dry; many, coarse, distinct, strong-brown (7.5YR 5/6) mottles; moderate, medium, granular structure and weak, thin, platy at top; friable; few fine gravel; medium acid; clear, wavy boundary. 0 to 6 inches thick.

Bg—12 to 30 inches, grayish-brown (2.5Y 5/2) light sandy loam; many, coarse, faint, gray (10YR 6/1) mottles; very weak, fine, granular structure; very friable; 10 percent hard rounded fine gravel; strongly acid; gradual, wavy boundary. 12 to 24 inches thick.

IIC—30 to 60 inches, grayish-brown (2.5Y 5/2) stratified gravelly loamy sand and gravelly sandy loam; single grained; loose; 20 percent rounded hard fine granitic gravel; strongly acid.

The solum ranges from 20 to 36 inches in thickness. Depth to bedrock is more than 6 feet. In the northern and western parts of the county, medium and coarse sand make up a higher proportion of the sand fraction in these soils than in other parts of the county. Medium and fine sand is more abundant in the lowlands around Pequannock and in the basin formerly occupied by glacial Lake Passaic. Generally, the coarse fragments consist mainly of granitic material, but in the lowlands east of a line connecting Morristown, Boonton, and Butler, the fragments are commonly red shale and traprock material. In areas that are not limed, reaction ranges from strongly acid to very strongly acid to a depth of 72 inches.

The matrix of the A horizon is 10YR to 2.5Y in hue, 2 or 3 in value, and 1 or 2 in chroma. The A horizon in places contains 0 to 10 percent gravel. In unplowed areas, the A1 horizon ranges from 6 to 12 inches in thickness.

The B horizon is 10YR to 2.5Y in hue, 4 to 5 in value, and 0 to 2 in chroma. This horizon is sandy loam or gravelly sandy loam. The content of gravel ranges from 5 to 20 percent.

The C horizon is 10YR to 2.5Y in hue, 5 to 7 in value, and 2 to 4 in chroma. This horizon is stratified sandy loam, loamy sand, sand, and their gravelly analogs. The content of gravel ranges from 0 to 50 percent, and the content of cobbles is 0 to 10 percent.

Preakness soils are associated with Bartley, Pompton, Adrian, Riverhead, and Parsippany soils. They have a low-chroma matrix in the B horizon, which Bartley, Pompton, and Riverhead soils do not have. Preakness soils consist of mineral materials, but Adrian soils consist of organic materials. They contain less clay and silt than Parsippany soils.

Preakness sandy loam, 0 to 4 percent slopes (PvA).—Included with this soil in mapping are small areas of Pompton and Adrian soils. Also included in Troy Meadows and in the Great Swamp, where Preakness soils are associated with Parsippany soils, are areas of a sandy soil that has a clayey substratum within a depth of 40 inches.

The large uniform areas of these nearly level soils, a sandy loam texture, and moderately rapid permeability make this soil suitable for a variety of uses. The presence of the water table at or near the surface for long periods during fall, winter, and spring and the hazard of infrequent flooding are limitations to the use of this soil.

In its natural condition, this soil is suited to woodland. It requires improved drainage for pasture, hay, and cultivated crops. Because of the low position of the soil, a high water table in the surrounding areas, and low relief, adequate outlets are difficult to find in many places. A water table that is seasonally high for long periods, susceptibility to ponding for long periods after heavy rains, and the hazard of flooding are the main limitations to use of the soil for community development. Capability unit IVw-36.

Preakness Variant

The Preakness variant, consists of deep, nearly level, very poorly drained, moderately coarse textured soils. These soils occupy low postions on the landscape, generally in small isolated kettles or other undrained depressions on terraces and pitted outwash plains. Near Pequannock and Succasunna they are in uniform, nearly level, moderately large swampy areas on outwash plains. They also occur in sandy and swampy areas in Troy and Black Meadows and the Great Swamp region of eastern Morris County. They formed in stratified and sorted glacial outwash.

In a representative profile the surface layer is black muck about 8 inches thick. The upper 10 inches of the subsoil is olive-gray coarse sandy loam, and the lower 14 inches is gray and dark-gray loamy coarse sand. The subsoil is mottled with strong brown and yellowish red. The substratum to a depth of 60 inches is varicolored, stratified sand and loamy sand.

Permeability is moderately rapid. The soils have a water table at or near the surface most of the year. During summer and in periods of long droughts, the water table drops to a depth of 2 to 3 feet, but it quickly rises in periods of heavy rains. In the northeastern part

of the county and along small streams, there is a hazard of infrequent flooding.

Undrained areas of the Preakness dark surface variant are too wet for farming and community developments. These soils are underlain by stratified sandy and gravelly material and are a source of sand, gravel, or fill. They serve as sites for dugout ponds. The soils can be drained by subsurface tile or by deep, widely spaced ditches, provided an outlet is available. Little of the acreage has been drained and cleared for crops. Most areas that were drained are now idle and are overgrown with brush and small trees. If crops are grown or the areas are used for community developments, intensive drainage systems and protection from flooding are required. Most areas are woodland.

Representative profile of Preakness sandy loam, dark surface variant, in a pasture along the drainage ditch 100 feet north of the Pequannock sewage treatment plant, 25 feet east of the plant's access road:

O2—8 inches to 0, black (N 2/0) fibrous muck; moderate, coarse, crumb structure; very friable; many fine, fibrous roots; very strongly acid; abrupt, smooth boundary. 6 to 15 inches thick.

B1g—0 to 2 inches, olive-gray (5Y 5/2) heavy sandy loam; few, medium and coarse, prominent, strong-brown (7.5YR 5/8 and 7.5YR 5/6) mottles; weak, medium, subangular blocky structure; friable; very few fine roots; some muck in old root channels and wormholes; very strongly acid; clear, smooth boundary. 0 to 4 inches thick.

IIB21g—2 to 10 inches, olive-gray (5Y 5/2) coarse sandy loam; common, coarse, prominent, strong-brown (7.5YR 5/6) mottles and few, medium, prominent, yellowish-red (5YR 4/8) mottles; weak, medium, subangular blocky structure; friable; very strongly acid; gradual, wavy boundary. 6 to 24 inches thick.

IIB22g—10 to 17 inches, gray (5Y 5/1) and dark-gray (5Y 4/1) loamy coarse sand; common, fine, prominent, strong-brown (7.5YR 5/6) mottles and few, fine, prominent, yellowish-red (5YR 4/8) mottles; very weak, medium, subangular blocky structure; very friable; very strongly acid; gradual, wavy boundary. 0 to 12 inches thick.

IIB3g—17 to 24 inches, gray (5Y 5/1) and dark-gray (5Y 4/1) loamy coarse sand and some fine gravel; single grained; loose; very strongly acid; clear, wavy boundary. 0 to 12 inches thick.

IIIC—24 to 60 inches, varicolored, stratified sand and loamy sand; 5 percent gravel; single grained; loose; sand grains are clean and unweathered quartz, feldspar, and dark-colored ferromagnesium minerals; very strongly acid.

The solum ranges from 20 to 50 inches in thickness. Depth to bedrock is more than 10 feet. The mineral fraction of the Preakness dark surface variants is generally granitic material, but in places in the eastern half of Morris County, the sand and gravel fraction is as much as 50 percent reddish shale, sandstone, and traprock. In areas that are not limed, reaction is very strongly acid to medium acid in the solum and extremely acid to medium acid in the C horizon.

In undisturbed areas the O horizon ranges from 6 to 15 inches in thickness. In plowed areas the Ap horizon ranges from 8 to 12 inches in thickness. The organic-matter content in the O and Ap horizons ranges from 15 to 50 percent but is generally about 25 percent.

The B horizon is dominantly loamy sand but ranges to heavy sandy loam and their gravelly analogs. This horizon is mainly gray and has mottles that range from few to many, fine to coarse, and distinct to prominent.

The C horizon has thin to thick strata of sandy loam, loamy sand, and sand that in most places contains some gravel. In a few places it contains 25 to 50 percent gravel and some cobbles.

The Preakness variants are associated with Muck, shallow over loam; Muck, shallow over clay; and Adrian, Preakness, Pompton, and Riverhead soils. They have a dark-colored mucky horizon, which other Preakness soils and Pompton and Riverhead soils do not have. They have a thinner organic layer than Adrian soils and Muck, shallow over clay, and Muck, shallow over loam.

Preakness sandy loam, dark surface variant (Pw).—This soil has slopes of 0 to 3 percent. Included in mapping are areas of Adrian, Preakness, and Pompton soils.

In its natural condition, this soil is too wet for farming or for community developments. Draining many of the small areas is impractical, but near Pequannock large uniform areas are drained and farmed. The low position of the soil on the landscape, a high water table, and a hazard of flooding limit the use of this soil for community development. Capability unit IVw-36.

Reaville Variant

The Reaville variant consists of deep, nearly level to gently sloping, moderately well drained and somewhat poorly drained shaly soils. These soils are in waterways, on gently sloping hillsides, and in seep spots at the base of steeper slopes. They formed in material weathered from the underlying shale bedrock or in local alluvium of similar material that washed from the surrounding slopes. Shale fragments occur throughout the profile and increase in size and number with increasing depth.

In a representative profile the surface layer is very dark grayish-brown shaly silt loam about 2 inches thick. The subsoil is shaly silt loam about 28 inches thick. The upper 6 inches of the subsoil is yellowish brown; the next 13 inches is reddish brown mottled with light yellowish brown, yellowish brown, and light brownish gray; and the lower 9 inches is dark reddish brown. The substratum is very shaly silt loam about 15 inches thick. Soft, fractured and weathered shale bedrock is at a depth of 45 inches.

Permeability is moderately slow, and available water capacity is high. These soils have good to poor workability, stability, and compaction characteristics where they are used for embankments or fill. Free water is at a depth of ½ foot to 4 feet late in winter, early in spring, and after heavy rains. Because of their low position on the landscape, the soils remain ponded for a brief period after heavy rains. The range of suitable crops is limited by seasonal wetness. Diversion of surface water and surface drainage improve uniformity of operations, promote good growth of crops, and allow a greater range of crops.

Drained areas of the Reaville variants are suited to corn, hay, and pasture. Improved drainage is needed if the soils are used for community development. In many places the soils are used for waterways, small ponds, or water storage areas for recreation, wildlife, or farm use. Most areas have been cleared for farming.

Representative profile of Reaville shaly silt loam, deep variant, 0 to 5 percent slopes, at the Mulverhill pond site on edge of woodlot, 200 feet east of Fox Hunt Road, 1,000 feet south of Lee's Hill Road, in Harding Township:

A1—0 to 2 inches, very dark grayish-brown (10YR 3/2) shaly silt loam; moderate, medium, granular structure; friable; many, fine, fibrous and large roots; 15 percent shale chips, less than ½ inch thick, that range from ¼ to 1 inch in diameter; slightly acid; clear, wavy boundary. 1 to 3 inches thick.

B1—2 to 8 inches, yellowish-brown (10YR 5/4) shaly silt loam; weak, fine, subangular blocky structure; friable; common, fine, fibrous roots and large roots; some channels and voids filled or stained with very dark grayish-brown (10YR 3/2) silty material from A1 horizon; 15 percent shale chips ¼ to 1 inch in diameter; strongly acid; gradual, wavy boundary. 0 to 10 inches thick.

B21t—8 to 15 inches, reddish-brown (5YR 4/4) shaly silt loam; common, coarse, faint, light yellowish-brown (10YR 6/4) mottles; weak, fine, subangular blocky structure; friable, slightly sticky, slightly plastic; common, fine, fibrous roots and few, large, feeder roots; discontinuous, slightly darker, semiglossy clay films on ped faces, films are not prominent and are less than 1 millimeter thick; 15 percent shale chips ½ inch to 2 inches in diameter; strongly acid; diffuse, wavy boundary. 6 to 10 inches thick.

B22t—15 to 21 inches, reddish-brown (5YR 4/4) shaly heavy silt loam; common, coarse, faint, yellowish-brown (10YR 5/4) mottles and few, medium, distinct, light brownish-gray (10YR 6/2) mottles; moderate, fine and medium, subangular blocky structure; friable, slightly sticky, slightly plastic; discontinuous, slightly darker, semiglossy, thin clay films on most ped faces, nearly all sand grains stained or coated; 20 percent shale chips ½ inch to 2 inches in diameter; medium acid; gradual, wavy boundary. 6 to 15 inches thick.

B3—21 to 30 inches, dark reddish-brown (2.5YR 3/4) shaly silt loam; massive; firm to friable and slightly brittle; dark reddish-brown semiglossy films on nearly all shale chips; 30 percent shale chips as much as 3 inches in diameter and 1 inch thick; slightly acid; diffuse, irregular boundary. 4 to 12 inches thick.

C—30 to 45 inches, dark reddish-brown (2.5YR 3/4) very shaly silt loam, 70 percent shale chips; shale chips that increase in size and hardness with increasing depth range from 1 inch to 6 inches in diameter and from ⅛ to 1 inch in thickness; slightly acid; diffuse, irregular boundary. 0 to 18 inches thick.

R—45 inches, dark reddish-brown (2.5YR 3/4), soft, weathered shale bedrock that becomes increasingly hard, less weathered, and fractured with increasing depth.

The solum ranges from 24 to 40 inches in thickness. Depth to bedrock is 3½ to 5 feet. In areas that are not limed, reaction is very strongly acid to slightly acid. The content of shale chips ranges from 5 to 20 percent.

The matrix of the A horizon is 10YR to 7.5YR in hue.

The B2 and B3 horizons are 7.5YR to 10R in hue. These horizons are commonly shaly silt loam and silty clay loam. The content of shale chips ranges from 5 to 45 percent and increases with depth.

A C horizon occurs in some places.

The Reaville variants are associated with Penn, Klinesville, Whippany, Parsippany, and Pompton soils. They are deeper than Penn and Klinesville soils. They have less clay in the B horizon than Parsippany and Whippany soils and less sand throughout than Pompton soils.

Reaville shaly silt loam, deep variant, 0 to 5 percent slopes (ReB).—This soil is in narrow, nearly level and gently sloping swales that extend into the uplands within Passaic Basin in the southern part of Morris County.

Included with this soil in mapping are small areas of more strongly sloping soils. Also included, in places, are areas of Penn and Whippany soils, a soil that has a fragipan, and areas of soils that are similar to this variant, but they have a surface layer of silt loam. Also included, along Glen Alpine Road northwest of New Vernon, is an extensive area of soils that are underlain by brown or yellowish-brown siltstone or sandstone bedrock and are distinctly more yellow throughout the profile than this soil. Except for a difference in color and depth, the moderately well drained and somewhat poorly drained soils in this area are similar to soils in the Reaville series.

Properties that affect the use of this Reaville deep variant for farming and landscaping are the somewhat poor drainage and its low position on the landscape. These properties, along with the silty texture, also affect the use of this soil for engineering and community development. Capability unit IIw-70.

Ridgebury Series

The Ridgebury series consists of deep, nearly level to gently sloping, poorly drained very stony or extremely stony soils. These soils are in shallow drainageways and depressions on the glaciated granitic uplands in the northwestern part of the county. They are mostly in elongated areas along streams and watercourses. The soils have a well-developed fragipan. They formed in glacial till derived largely from granitic gneiss and a small amount of micaceous gneiss and many kinds of quartzite, sandstone, and shale.

In a representative profile the surface layer is about 9 inches thick. The upper 4 inches of the surface layer is black gravelly loam, and the lower 5 inches is mottled, light yellowish-brown sandy loam. The upper part of the subsoil, to a depth of about 14 inches, is mottled, light brownish-gray gravelly light sandy loam. The lower part is a very firm and dense fragipan that is light olive-brown gravelly light sandy loam to a depth of about 26 inches and dark yellowish-brown gravelly sandy loam between depths of 26 and 31 inches. The upper 5 inches of the substratum is part of the fragipan and is dark yellowish-brown gravelly sandy loam. Below this the substratum to a depth of 60 inches is varicolored, friable gravelly sandy loam.

Permeability is moderate above the fragipan and slow in the fragipan. The soils have good workability, stability, and compaction characteristics. They are only slightly compressible and have low subsidence. The water table is at or near the surface during most of winter and in spring, and the soils are usually too wet to work, which limits their suitability as a source of borrow material. In low nearly level areas they are subject to seasonal ponding and frequently remain ponded for long periods. Roots are common and are distributed throughout the soil above the fragipan but are rare within or below the fragipan. The available water capacity is moderate, but water stored below the fragipan is generally not available for use by plants.

Nearly all the acreage of Ridgebury soils is covered with oak, birch, ash, and elm. The soils are used mainly for trees, State or county parks, and other similar open-space purposes. Because of their low position, where they receive runoff from surrounding higher areas, and because of their high water table, the soils are natural sites for ponds and reservoirs.

Representative profile of Ridgebury gravelly loam in an area of Ridgebury extremely stony loam, 3 to 10 percent slopes, in a wooded area, 300 feet southwest of New Jersey Route No. 23 along the drainage ditch between Kiel and Maple Lake Roads near Butler:

A1—0 to 4 inches, black (N 2/0) gravelly loam; moderate, fine and medium, granular structure; very friable; many, fine, fibrous roots and large conductor roots; 20 percent gravel, cobbles, and stones; strongly acid; clear, smooth boundary. 2 to 6 inches thick.

A3—4 to 9 inches, light yellowish-brown (10YR 6/4) heavy sandy loam; very dark gray (5Y 3/1) organic stains along root channels and in voids; many, fine and medium, faint, brownish-yellow (10YR 6/6) mottles; weak, medium, subangular blocky structure; friable; many, fine, fibrous roots and large conductor roots; many sand grains; some ped faces are clean and unstained; strongly acid; clear, smooth boundary. 0 to 6 inches thick.

B2g—9 to 14 inches, light brownish-gray (2.5Y 6/2) gravelly light sandy loam; many, fine and medium, distinct, yellowish-brown (10YR 5/6) mottles and few, coarse, faint, brown (10YR 4/3) mottles; weak and moderate, medium, subangular blocky structure; friable; common, fine, fibrous roots and small conductor roots; grayish ped faces; black (10YR 2/1) iron and manganese stains around some weathered pebbles and sand grains; 30 percent gravel, cobbles, and stones, dominantly granitic gneiss and fragments of various other kinds of rock; medium acid; gradual, wavy boundary. 4 to 18 inches thick.

Bx1—14 to 26 inches, light olive-brown (2.5Y 5/4) gravelly light sandy loam; many, medium, faint, light-brownish-gray (2.5Y 6/2) and distinct, yellowish-brown (10YR 5/6) mottles; moderate, very thick, platy structure; very firm; few roots, where present they are in association with the grayish color bands; ped faces are gray colored; sand grains in the yellowish-brown bands have semiglossy translucent coated or stained surfaces; 30 percent gravel, cobbles, and stones, largely granitic gneiss; strongly acid; clear, smooth boundary. 6 to 24 inches thick.

Bx2—26 to 31 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam; weak, very thick, platy structure; very firm; less than 2 percent very narrow horizontal bands of yellowish-brown (10YR 5/6) and light brownish gray (2.5Y 6/2) along structural surfaces; prominent, black-colored, manganese stains around large sand grains and pebbles; 35 percent gravel, cobbles, and stones; strongly acid; clear, smooth boundary. 0 to 12 inches thick.

C1x—31 to 36 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam; many brown (7.5YR 4/4) and few light brownish-gray (2.5Y 6/2) mottles; massive; very firm; 20 percent gravel, cobbles, and stones; strongly acid; clear, smooth boundary. 0 to 18 inches thick.

C2—36 to 60 inches, varicolored yellowish-brown, dark yellowish-brown, light olive-brown, and olive-brown gravelly sandy loam in hue of 10YR and 2.5Y, value of 4 or 5, and chroma of 4; massive; friable; most sandy grains are clean and uncoated, but discontinuous general stains are in some parts of this horizon; 35 percent coarse fragments composed of 20 percent gravel, 15 percent cobbles, and a few stones; strongly acid.

The solum ranges from 20 to 40 inches in thickness. Depth to the fragipan ranges from 12 to 24 inches. The fragipan is well developed, is very firm to extremely firm, and has platy structure or is massive. It is in the lower part of the B horizon and commonly extends into the C horizon. The matrix of all horizons is 10YR to 2.5Y in hue. Angular gravel, cobbles, and stones range from 20 to 35 percent. The content of cobbles exceeds the content of gravel in many places. Boulders occur extensively. Low-chroma colors are dominant in the upper part of the B horizon, and the proportion of low chroma decreases with increasing depth. In areas that are not limed, reaction ranges from very strongly acid to medium acid. The solum ranges from gravelly sandy loam to gravelly loam.

Ridgebury soils are associated with Hibernia, Whitman, Rockaway, Netcong, and Adrian soils. They have a B horizon that has a low-chroma matrix, which Hibernia, Rockaway, and Netcong soils lack. They do not have the thick, black A horizon that is common in Whitman soils. They lack the organic layers that are common in Adrian soils.

Ridgebury very stony loam, 0 to 3 percent slopes (RgA).—This soil has a profile similar to the one described as representative of the series, but the surface layer is thicker. Included in mapping are areas of more strongly sloping and nonstony Ridgebury soils and of Hibernia and Whitman soils.

In many places this nearly level soil is in depressions that receive runoff from surrounding areas, and outlets are not available for surface water. In many places a thin mantle of recent alluvium has washed from surrounding higher areas. The alluvium is free of coarse fragments. The subsoil and generally the surface layer are as much as 50 percent stones, cobbles, and gravel. Stones on the surface are spaced 5 to 30 feet apart. Boulders are commonly on top of and throughout the soil.

This soil is not suited to cultivation or to community developments unless the stones are removed and drainage is improved. In its natural condition, the soil is generally restricted to use as wildlife habitat or woodland. Because of its low position and a high water table, in many places the soil is used for ponds and reservoirs. Capability unit VIIs-38.

Ridgebury extremely stony loam, 3 to 10 percent slopes (RlB).—This soil has the profile described as representative of the series. Included in mapping are small areas of Hibernia soils, less stony and less sloping Ridgebury soils, and Whitman soils.

This gently sloping soil is at the base of slopes, where it receives runoff and seepage from higher areas. Unless the areas are protected, the hazard of erosion is moderate but inasmuch as most areas are wooded, erosion is only a slight hazard. Stones in the soil interfere with the use of farming equipment, excavating, and logging operations. They are spaced less than 5 feet apart.

This soil is not suited to cultivation. It is better suited to woodland and wildlife than to other uses. It has limitations for community development. Capability unit VIIs-38.

Riverhead Series

The Riverhead series consists of well-drained, nearly level to strongly sloping gravelly soils. These soils are generally on undulating outwash terraces and plains and in valleys and basins within and near the granitic highlands. They are also on small isolated moraines. The soils formed in sandy and gravelly outwash derived mainly from granitic material that contains a small amount of shale, sandstone, quartzite, and conglomerate.

In a representative profile the surface layer is very dark grayish-brown gravelly sandy loam about 2 inches thick. The upper 6 inches of the subsoil is dark-brown gravelly sandy loam. Below this, the subsoil is yellowish-brown gravelly sandy loam about 20 inches thick. The substratum to a depth of 60 inches is very friable to loose, yellow and very pale brown gravelly loamy sand and loamy sand.

Permeability is moderately rapid, and available water capacity is moderate. Depth to the water table is more than 10 feet. Where these soils are used for construction, the material is workable and compacts well under a wide range of moisture conditions. The soils are slightly compressible. They are underlain by loose, unweathered, stratified and sorted sand and gravel, which is rapidly permeable. The soils are a source of sand, gravel, and fill.

Nearly level and gently sloping Riverhead soils are suited to corn, small grain, hay, and most specialty crops grown in the county. More sloping Riverhead soils are generally wooded. The common trees are white, black, and red oaks; beech; maple; hickory; and ash. Most Riverhead soils are used for urban developments.

Representative profile of Riverhead gravelly sandy loam, 3 to 8 percent slopes, in a gravel pit, 50 feet east of Berkshire Valley Road, 1 mile south of Woodstock:

A1—0 to 2 inches, very dark grayish-brown (10YR 3/2) gravelly sandy loam; moderate, medium, granular structure; friable; 15 percent gravel and 5 percent cobbles, mostly fresh granitic material; pebbles and sand grains are mostly uncoated except for dark organic stains; very strongly acid; clear, wavy boundary. 1 to 3 inches thick.

B1—2 to 4 inches, dark-brown (7.5YR 4/4) gravelly sandy loam; very weak, medium, subangular blocky structure parting to moderate, fine, granular; very friable; 15 percent gravel and 5 percent cobbles; very strongly acid; clear, wavy boundary. 0 to 6 inches thick.

B21—4 to 8 inches, dark-brown (7.5YR 4/4) gravelly sandy loam; weak, medium, subangular blocky and moderate, fine, granular structure; friable; gravel and sand grains have a very thin translucent coating or stain of silt and clay; 15 percent gravel and few cobbles; very strongly acid; abrupt, wavy boundary. 4 to 16 inches thick.

B22—8 to 28 inches, yellowish-brown (10YR 5/4) gravelly sandy loam; massive; friable or very friable; 30 percent gravel and cobbles; most sand grains are clean, bridges are absent except in perched mounds on top of larger pebbles; very strongly acid; diffuse, wavy boundary. 4 to 24 inches thick.

IIC1—28 to 33 inches, yellow (10YR 7/6) gravelly loamy sand; massive; very friable; 20 percent gravel and cobbles; discontinuous coatings or stains on top of pebbles, most sand grains are clean; very strongly acid; gradual, wavy boundary. 0 to 6 inches thick.

IIC2—33 to 60 inches, very pale brown (10YR 7/4), pale-yellow (2.5Y 7/4), and yellow (2.5Y 7/6) loamy sand; single grained; loose; 10 percent gravel; pebbles and sand grains are clean and uncoated; strongly acid.

The solum ranges from 24 to 36 inches in thickness. Depth to bedrock is more than 10 feet. Coarse fragments make up 5 to 15 percent of the A horizon and the upper part of the B horizon and 5 to 40 percent of the C horizon. In areas that are not limed, reaction ranges from strongly acid to very strongly acid throughout. Pebbles and sand grains derived mostly from granitic gneiss and are dominantly feldspar, quartz, and a small amount of darker colored ferromagnesian mineral. In addition, some sandstone, quartzite, shale, and conglomerate pebbles and sand grains are present. In the eastern part of Morris County, the soils contain a high proportion of red and brown shale and fine-grained traprock fragments. In this area the soils have a slightly higher proportion of medium and fine sand and are likely to have pockets, lenses, or strata of silty or very fine sandy material in the C horizon.

The A1 and Ap horizons are 10YR or 7.5YR in hue, 3 or 4 in value, and 2 or 3 in chroma.

The B horizon ranges from 10YR to 7.5YR in hue, 4 to 6 in value, and 4 to 6 in chroma. This horizon is mainly sandy loam or gravelly sandy loam, but it ranges to loamy sand in the B3 horizon. In some places there is no B3 horizon. The lower boundary of the B2 horizon is wavy and has tongues, 4 to 8 feet apart, that extend as much as 10 inches into the underlying B3 or C horizon.

The IIC horizon is loose, mostly unweathered, stratified gravel and sand.

Riverhead soils are associated with Otisville, Rockaway, Edneyville, Parker, Pompton, Boonton, Parsippany, and Whippany soils. They are not so sandy as Otisville soils. Riverhead soils are underlain by sorted and stratified sedimentary deposits, but Rockaway soils are underlain by glacial till and Parker and Edneyville soils by weathered residuum. Riverhead soils lack the mottles that are common in Pompton and Boonton soils. They are not so fine textured as Parsippany and Whippany soils.

Riverhead gravelly sandy loam, 0 to 3 percent slopes (RmA).—This soil is on wide terraces in valleys and on knolls on broad, low outwash plains. Included in mapping are small areas of Pompton and Preakness soils, both of which have poor drainage. Also included, near Succasunna and Kenvil, are areas of a soil that has a high proportion of medium sand, no gravel, and a yellowish-red subsoil.

Properties of this soil that affect its use for farming and landscaping are its moderately coarse texture, the content of gravel and cobbles, the moderately rapid permeability, and the moderate available water capacity. For high-value crops, irrigation is generally beneficial. This soil is a source of sand, gravel, and borrow material for road fill and embankments. Capability unit I-7.

Riverhead gravelly sandy loam, 3 to 8 percent slopes (RmB).—This soil has the profile described as representative of the series. Included in mapping are small areas of Otisville and Pompton soils, both of which have poor drainage. Also included, near Succasunna and Kenvil, are areas of a soil that has a high proportion of medium sand, no gravel, and a yellowish-red subsoil.

This soil is suited to small grain, corn, hay, pasture, and most specialized vegetable crops grown in the county. Deep-rooted, drought-resistant plants, such as alfalfa, Ladino clover, orchardgrass, and bromegrass are suitable. This undulating soil has a moderate hazard of erosion. Conservation practices that have been used to reduce erosion include crop rotation, contour cultivation, and stripcropping. Irrigation is generally beneficial for high-value crops. Limitations are few for most community development. This soil is a source of sand, gravel, and borrow material for road fill and embankments. Capability unit IIe-7.

Riverhead gravelly sandy loam, 8 to 15 percent slopes (RmC).—This soil has more complex slopes than gently sloping Riverhead soils. Included in mapping are small areas of Otisville and Rockaway soils. Also included, near Succasunna and Kenvil, are areas of a soil that

has a high proportion of medium sand, no gravel, and a yellowish-red subsoil.

The main properties of this soil that affect its use are strong slopes, moderately coarse texture, content of gravel and cobbles, moderately rapid permeability, moderate available water capacity, and a moderately high hazard of erosion.

This soil is suited to small grain, hay, and pasture, but it has limitations to use for corn and specialized crops. Conservation practices that help to reduce erosion include using crop rotation, contour cultivation, stripcropping, and diversions. In places steepness of slope is a limitation for community development. Capability unit IIIe-7.

Riverhead Variant

The Riverhead variant consists of deep, nearly level to gently sloping, well-drained soils on gently rolling terraces along the Muscenetcong and South Branch of the Raritan River. These soils formed in sorted and stratified gravelly loamy sand that derived mostly from granitic material that contains various kinds of rock fragments, including limestone. In most places common cobbles and less than 1 percent stones and boulders are scattered on the surface and throughout the soil.

In a representative profile the surface layer is dark grayish-brown gravelly sandy loam about 10 inches thick. To a depth of about 30 inches, the subsoil is strong-brown gravelly sandy loam. Below this the subsoil, to a depth of about 38 inches, is dark-brown and yellowish-brown gravelly loamy sand. The substratum to a depth of 66 inches is yellowish-brown and dark yellowish-brown gravelly loamy sand.

Permeability is moderately rapid, and available water capacity is moderate. These soils have good workability, stability, and compaction characteristics; low compressibility; and low subsidence. Depth to the water table is related to the elevation above the stream, generally 6 to 10 feet.

Areas of the Riverhead variant are used for truck crops, dairying, and general farming. Most areas, such as those near Hackettstown, are idle or are used for commercial and residential purposes. The native vegetation is oak and hickory. Nearly level to gently sloping areas of the Riverhead variant are suitable for intensive and general farming, but they are limited for crops because of moderate available water capacity and high rate of leaching of added fertilizer. Good drainage, ease of excavation, and grading make them suitable for community developments. The cobbles and stones in a few places affect landscaping and grading.

Representative profile of Riverhead gravelly sandy loam, neutral variant, 2 to 8 percent slopes, in a pasture, 500 feet southwest of Flocktown-Naughright Road, 70 feet south of the Central Railroad of New Jersey's tracks, in the community of Naughright:

Ap—0 to 10 inches, dark grayish-brown (10YR 4/2) gravelly sandy loam; weak, thick, platy structure parting to moderate, medium, granular; very friable, nonsticky, nonplastic; many fine, fibrous roots; 25 percent gravel and cobbles, mostly granitic gneiss, shale, or weathered limestone and a smaller quantity of quartzite, sandstone, and chert; strongly acid; abrupt, smooth boundary. 6 to 10 inches thick.

B1—10 to 18 inches, strong-brown (7.5YR 5/6) gravelly sandy loam; weak; medium, subangular blocky structure; friable, nonsticky, nonplastic; many, fine, fibrous roots; 25 percent gravel and cobbles, mostly granitic gneiss, shale, or weathered limestone and a smaller quantity of quartzite, sandstone, and chert; medium acid; gradual, wavy boundary. 4 to 10 inches thick.

B2—18 to 30 inches, strong-brown (7.5YR 5/6) gravelly sandy loam; weak, medium, subangular blocky structure; friable, slightly sticky, nonplastic; common, fine, fibrous roots; 30 percent gravel and cobbles, mostly granitic gneiss, shale, and weathered limestone and a smaller amount of quartzite, sandstone, and chert; medium acid; clear, wavy boundary. 8 to 18 inches thick.

B3—30 to 38 inches, dark-brown (7.5YR 4/4) and yellowish-brown (10YR 5/6) gravelly loamy sand; single grained; nonsticky, nonplastic; few fibrous roots; 30 percent gravel and cobbles, mostly granitic gneiss, shale, and limestone and a smaller amount of quartzite, sandstone, and chert; most sand grains are stained with translucent dark brown or yellowish brown; slightly acid; gradual, wavy boundary. 4 to 12 inches thick.

C—38 to 66 inches, nearly equal parts of yellowish-brown (10YR 5/6) and dark yellowish-brown (10YR 4/4) gravelly loamy sand and a sprinkling of light and dark sand grains; single grained; nonsticky, nonplastic; 45 percent gravel and cobbles, mostly granitic gneiss, shale, and limestone and a smaller quantity of various other rock types; neutral; calcareous sand grains and pebbles.

The solum ranges from 24 to 40 inches in thickness. Coarse fragments make up 10 to 35 percent of the A and B horizons and 10 to 50 percent of the C horizon. Granitic gneiss is dominant, but limestone chips also occur. In a few places sandstone, quartzite and shale are nearly as abundant as granitic gneiss. In areas that are not limed, reaction is strongly acid in the A horizon but is neutral within a depth of 40 inches.

The A1 and Ap horizons are dark brown (7.5YR 3/2) to dark grayish brown (10YR 4/2) and range from 2 to 10 inches in thickness. Where the A horizon has a value of 3, it is generally 2 to 4 inches thick.

The B horizon is brown (7.5YR 4/4) to yellowish brown (10YR 5/6). In many places it contains slightly more clay than the A horizon.

The C horizon reflects the color of individual sand grains in a salt and pepper pattern. The overall appearance is yellowish brown (10YR 5/6) to dark yellowish brown (10YR 4/4). This horizon is stratified very gravelly sand to gravelly loamy sand.

The Riverhead variants are associated with Bartley, Pompton, and Turbotville soils and Alluvial land. They do not have the low-chroma mottles that are common in Pompton soils. They lack the fragipan that is common in Bartley and Turbotville soils. They occupy positions on the landscape that are above the normal flood levels that occur on Alluvial land.

Riverhead gravelly sandy loam, neutral variant, 2 to 8 percent slopes (RnB).—This soil is on wide terraces in limestone valleys. Included in mapping are small areas of steeper soils and Pompton and Bartley soils.

This soil is suited to general and dairy farming. Deep-rooted, drought-resistant plants, such as alfalfa, orchardgrass, and bromegrass, are suitable. For intensive specialized crops and golf fairways, irrigation is beneficial. This soil is well suited to community development. The substratum of this soil is rapidly permeable and is underlain by open-jointed or fractured limestone bedrock. If this soil is used for onsite disposal of sewage

or industrial waste, groundwater pollution is a hazard. Capability unit IIe-7.

Rockaway Series

The Rockaway series consists of deep, gently sloping to very steep, well drained and moderately well drained soils on uplands. These soils have a moderately developed fragipan. They formed in sandy loam glacial till that contains various kinds of rock but is mainly granitic material.

In a representative profile the surface layer is very dark grayish-brown cobbly sandy loam about 8 inches thick. The upper part of the subsoil is strong-brown gravelly sandy loam about 12 inches thick, and the lower part is a fragipan of mottled, strong-brown, firm and brittle gravelly sandy loam about 16 inches thick. The upper 4 inches of the substratum is part of the fragipan and is pale-brown, very firm gravelly sandy loam. Below this the substratum to a depth of 60 inches is pale-brown, loose gravelly sandy loam that contains stones and cobbles.

Permeability is moderate above the fragipan and slow in the fragipan. These soils have good workability, stability, and compaction characteristics; low compressibility; and low subsidence. In places the removal of stones and boulders is needed if these soils are used for embankments and subgrade and as homesites. In many places water perches on top of the fragipan moves laterally as seepage, particularly in winter, early in spring, and after heavy rains. Above the fragipan, roots can penetrate easily and are distributed throughout the profile, but the fragipan restricts penetration of roots. Available water capacity is moderate to low, and water stored below the fragipan is generally not available for use by plants.

Coarse fragments, shallow root zone, moderate to low available water capacity, and irregular topography restrict the use of these soils for cultivated crops and pasture. Extensive areas of Rockaway soils are woodland. They support oak, hickory, birch, yellow-poplar, ash, basswood, elm, and some hemlock. These soils are well suited to white pine, which has been planted in some abandoned fields. If these soils are used for community development, water is likely to seep along the top of the fragipan into the foundations of houses and roads and to the surface of road cuts and steep banks. On steeper slopes erosion during and after construction is a hazard. In places cobbles, stones, and boulders interfere with grading and landscaping. Boulders are particularly difficult to move, but they have been used for landscaping and for other esthetic purposes. Poor drainage is generally not a limitation for farming or for community development, but for special or intensive uses, seepage water needs to be intercepted.

Representative profile of Rockaway cobbly sandy loam in an area of Rockaway very stony sandy loam, 3 to 15 percent slopes, 1,000 feet west of Howard Boulevard along a road cut 1,000 feet south-southwest of Mt. Arlington Township School:

O2—1 inch to 0, very dark grayish-brown (10YR 3/2) decomposed plant material; 5 percent stones and cobbles, mostly granitic gneiss.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) cobbly sandy loam; weak, fine and medium, granular structure; very friable; nearly all sand grains and peds have dark organic stains on surface; 20 percent gravel and cobbles, 3 percent stones; very strongly acid; gradual, wavy boundary. 1 to 3 inches thick.

A3—4 to 8 inches, nearly equal proportions of very dark grayish-brown (10YR 3/2) and strong-brown (7.5YR 5/6) cobbly sandy loam; weak, fine and medium, subangular blocky structure; friable; very dark grayish-brown material extends along root channels and voids to the bottom of this horizon; 25 percent gravel and cobbles, 3 percent stones; very strongly acid; gradual, wavy boundary. 3 to 6 inches thick.

B21t—8 to 12 inches, strong-brown (7.5YR 5/6) gravelly heavy sandy loam; moderate, medium, subangular blocky structure; friable to slightly firm; 30 percent gravel, cobbles, and stones, largely granitic gneiss and red conglomerate; most sand grains have thin glossy stains or films; thin, discontinuous, glossy clay films on ped faces are slightly redder than matrix; very strongly acid; clear, irregular boundary. 3 to 10 inches thick.

B22t—12 to 20 inches, strong-brown (7.5YR 5/6) gravelly sandy loam; moderate, medium, subangular blocky structure; friable to slightly firm; thin discontinuous clay films on some ped faces; 20 percent gravel, cobbles, and stone; very strongly acid; clear, wavy boundary. 6 to 12 inches thick.

Bx—20 to 36 inches, strong-brown (7.5YR 5/6) gravelly sandy loam; common, medium, faint, brown (7.5YR 5/4) and reddish-brown (5YR 5/4) mottles; strong, very thick, platy structure; firm, brittle; very thick, reddish-brown (5YR 5/4), discontinuous, glossy films on horizontal surfaces and in voids; 30 percent gravel, cobbles, and stones; very strongly acid; clear, wavy boundary. 6 to 18 inches thick.

C1x—36 to 40 inches, pale-brown (10YR 6/3) gravelly light sandy loam; massive; very firm, very compact, slakes rapidly in water; 35 percent gravel, cobbles, and stones; very strongly acid; diffuse, wavy boundary.

C2—40 to 60 inches, pale-brown (10YR 6/3) gravelly light sandy loam; single grained; loose; 45 percent gravel, cobbles, and stones; very strongly acid.

The solum ranges from 30 to 40 inches in thickness. Depth to the top of the fragipan ranges from 18 to 30 inches, and thickness of the fragipan ranges from 12 to 28 inches. In many places the fragipan extends into the C horizon. Depth to bedrock is 10 feet or more. Angular or rounded pebbles, cobbles, stones, and large boulders are scattered over the surface and throughout the profile in most places. These coarse fragments make up 10 to 35 percent of the solum and as much as 50 percent of the C horizon. They are mostly granitic gneiss, but in many places they include a large proportion of red quartzite, traprock, sandstone, and a number of other rocks. In areas that are not limed, reaction is very strongly acid to strongly acid throughout.

The A horizon is 10YR to 7.5YR in hue, 3 or 4 in value, and 2 or 3 in chroma. It ranges from sandy loam to loam and their gravelly analogs. In places it is very stony and extremely stony.

The B horizon ranges from brown to strong brown. It is 7.5YR to 10YR in hue, 4 or 5 in value, and 6 to 8 in chroma. It is commonly gravelly sandy loam but ranges to gravelly loam in some subhorizons. In most places some faint mottles occur, especially in the upper part of the fragipan. The mottles are 5YR to 7.5YR in hue, 4 or 5 in value, and 3 to 8 in chroma. Structure is commonly moderate or strong, medium or coarse, subangular blocky and moderate or strong, thick or very thick, platy.

The color of the C horizon is difficult to determine, because of multicolored sand grains. The sand grains are yellowish red, brown, strong brown, light gray, and black. They have the appearance of salt and pepper, but the overall color is pale brown. The C horizon ranges from gravelly loamy sand to gravelly sandy loam.

Rockaway soils are near Hibernia, Ridgebury, Netcong, Riverhead, and Otisville soils. They do not have the distinct and prominent, high- and low-chroma mottles that are common in Hibernia soils. They do not have the low-chroma matrix color of Ridgebury soils. Rockaway soils have a fragipan, which Netcong, Riverhead, and Otisville soils lack.

Rockaway gravelly sandy loam, 3 to 8 percent slopes (RoB).—This soil has a profile similar to the one described as representative of the series, but it has fewer stones on the surface and in the profile. The subsoil and the substratum are nearly 30 percent stones, cobbles, and boulders.

Included with this soil in mapping are areas of more strongly sloping or less sloping Rockaway soils, more stony Rockaway soils, and Hibernia and Netcong soils.

Runoff is moderate, and the hazard of erosion is slight. Available water capacity is moderate.

In cultivated areas practices are needed to control runoff and erosion. Suitable conservation practices include use of cover and sod crops, cultivating on the contour, stripcropping on the longer slopes, and removing stones. In areas used for community development, establishing lawns or other plant cover early during development and breaking the longer slopes with diversions or streets are recommended. Boulders or stones encountered when excavating for foundations or road cuts make excavation difficult in some areas, and disposal of the boulders and stones is a problem. Capability unit IIe-5.

Rockaway gravelly sandy loam, 8 to 15 percent slopes (RoC).—This gently rolling soil has a profile similar to the one described as representative of the series, but the surface layer is less stony. The subsoil is about 30 percent coarse fragments.

Included with this soil in mapping are areas of Hibernia and Netcong soils, more strongly sloping or less sloping Rockaway soils, and stony and very stony Rockaway soils.

Runoff is rapid, and the hazard of erosion is moderate. Available water capacity is moderate to low.

This soil is suited to general crops and hay. If this soil is farmed, conservation practices are needed to control runoff, reduce erosion, and provide good growth of crops. Suitable practices are contour stripcropping, constructing diversions, and growing sod or close-growing crops in a rotation. In areas used for community developments, growing a temporary grass cover to protect cleared areas prior to rough grading and landscaping, establishing lawns and other plant cover early during the development, breaking slopes with diversions or cross streets, and constructing temporary or permanent desilting basins are suitable practices to help control runoff and to reduce erosion. Capability unit IIIe-5.

Rockaway very stony sandy loam, 3 to 15 percent slopes (RpC).—This gently rolling soil has the profile described as representative of the series. About 3 percent of the surface is covered by stones and a few boulders. The subsoil and substratum are nearly 30 percent coarse fragments. Stones on the surface are 5 to 30 feet apart.

Included with this soil in mapping are small areas of less stony and less sloping Rockaway soils, Hibernia soils, and other soils that lack a fragipan and that have a thinner surface layer and subsoil than this Rockaway soil. Also included are many areas of soils that have small outcrops of bedrock that are difficult to distinguish from the large boulders. On Greenpond Mountain there is about 400 acres of soils that are similar to this Rockaway soil, but they have a high proportion of siliceous minerals, are redder, contain red quartzite coarse fragments, and are underlain by red quartzite bedrock.

Runoff is moderate, and the erosion hazard is moderate. The available water capacity is low.

This soil is suited to pasture, trees, recreation, and open-space activities. If this soil is used for community developments, boulders and stones encountered during excavation and grading make excavation difficult and commonly their disposal is a problem. In addition, seepage along the top of the fragipan is likely to enter foundations or deep cuts. To control runoff and erosion, most builders adapt their developments to the terrain and use the slopes, stones, and boulders in their landscaping plans. Growing a temporary grass cover to protect cleared areas prior to rough grading and landscaping, establishing lawns and other plant cover early during development, and breaking slopes with diversions or cross streets are recommended practices to help control runoff and erosion. Interceptor and foundation drains to carry away seepage are also effective. Capability unit VIs-19.

Rockaway extremely stony sandy loam, 15 to 25 percent slopes (RrD).—This soil has a profile similar to the one described as representative of the series, but it contains more stones. Stones and boulders cover 10 percent of the surface and are 5 to 30 feet apart. In places bedrock crops out. The subsoil is nearly 30 percent coarse fragments.

Included with this soil in mapping are areas of less stony Rockaway soils and of gently rolling Rockaway extremely stony sandy loam. Also included, in the vicinity of Stevens State Park, are soils that are neutral or alkaline in reaction at a depth of about 50 inches, and they contain limestone fragments throughout. On Greenpond Mountain there are soils that are similar to this Rockaway soil, but they have a high proportion of siliceous minerals, are redder, and are underlain by red quartzite bedrock.

Runoff is rapid, and the erosion hazard is severe. The available water capacity is low. If this soil is used for community development, seepage along the top of the fragipan is likely to enter excavations or flow over the surface of steep cuts.

This soil is suited to woodland, recreation, and open-space activities (fig. 11). If it is used for community developments, stones, boulders, or bedrock encountered during excavation or grading are likely to make it very difficult to achieve the desired grade and depth of excavation. In addition, disposal of the coarse fragments uncovered during excavation is commonly a problem. Most builders adapt their development and landscaping plans to the topography, taking into account the slopes, stones, and boulders. Use of sequential clearance and development, division of long slopes by use of diver-

Figure 11.—**Ski slope on Rockaway extremely stony sandy loam, 15 to 25 percent slopes.**

sions or cross streets, and use of temporary or permanent sedimentation basins are beneficial in controlling erosion, runoff, and sedimentation. Interceptor drains at the top of cuts and foundation drains are effective in carrying away seepage. Capability unit VIIs-22.

Rockaway-Rock outcrop complex, 3 to 15 percent slopes (RsC).—This complex is 65 to 90 percent Rockaway soils and 10 to 35 percent Rock outcrop. The Rockaway soils are extremely stony and bouldery. Nearly 30 percent of the profile is gravel, cobbles, and other loose coarse fragments.

Included with this complex in mapping are a few small areas of Hibernia soils and less stony Rockaway soils. Included in places where slopes are more strongly sloping are short, low rock escarpments.

Runoff is moderately rapid, and the erosion hazard is moderate. Available water capacity is low.

This complex is used mainly as woodland, for recreation, and for open-space activities. The outcrops of bedrock and the high proportion of very coarse fragments are likely to interfere with excavation or grading for community developments. In addition, seepage along the top of the fragipan is likely to enter foundations or deep cuts, causing drainage problems or making slopes unstable. To help control runoff and erosion, most developers fit their developments to the terrain and use the slopes, stones, and boulders in their landscaping plans. If extensive areas are cleared during construction, use of temporary cover or early establishment of lawns is recommended. Interceptor drains at the top of cuts and foundation drains are effective in carrying away seepage. Capability unit VIIs-22.

Rockaway-Rock outcrop complex, 15 to 25 percent slopes (RsD).—This complex is 50 to 75 percent Rockaway soils and 25 to 50 percent Rock outcrop. The Rockaway soils are extremely stony and bouldery.

Included with this complex in mapping are areas of less sloping and less stony Rockaway soils. Also included are many areas that have short, low bedrock escarpments.

Runoff is rapid, and the hazard of erosion is moderately severe in cleared areas. The available water capacity is low. Also, seepage along the top of the fragipan is likely to enter excavations or flow over the surface in steep cuts.

The soils in this complex are used mainly as woodland, for recreation, and for open-space activities. Use of this complex for community development is generally restricted to widely spaced, specially selected residential sites between the rock outcrops. Stones, boulders, and bedrock encountered when excavating or grading for building foundations or road subgrades make it difficult to achieve the desired grade and depth of excavation. Disposal of the coarse fragments uncovered during excavation is commonly a problem. If large tracts are developed, sequential clearing and developing, dividing long slopes by use of diversions or cross streets, and using temporary or permanent sedimentation basins help to control erosion, runoff, and sedimentation. Interceptor drains at the top of cuts and foundation drains are effective in carrying away seepage. Rock outcrops are so numerous that they limit the alternatives for the vertical and horizontal alignment of streets and driveways and for the location of houses and other structures. Capability unit VIIs-22.

Rockaway-Rock outcrop complex, 25 to 45 percent slopes (RsE).—This complex is 60 to 80 percent Rockaway soils and 20 to 40 percent Rock outcrop. The subsoil

and the substratum of the Rockaway soils are nearly 30 percent coarse fragments. Slopes are mainly 25 to 30 percent in most areas, but in some areas slopes are as much as 45 percent.

Included with this complex in mapping are areas of more gently sloping Rockaway extremely stony sandy loam and less stony Rockaway soils.

Runoff is rapid, and the hazard of erosion is severe. The available water capacity is low.

The soils in this complex are not suitable for farming. Limitations for wood crop production and harvesting are severe. This complex is suited mainly to recreation and to wildlife habitat. Limitations for most community developments are severe. Capability unit VIIIs-23.

Rock Outcrop

Rock outcrop (Rt) consists of Green Pond Conglomerate escarpment associated with Green Pond Mountain, including a small area of rubble at the base of the escarpment. These areas are mostly rock and have no value for farming and little value for trees. They have some value for wildlife habitat and have potential for such recreational purposes as open space and hiking trails that have scenic overlooks. Capability unit VIIIs-23.

Rock outcrop-Rockaway complex, steep (RvF).—This land type is about 50 to 90 percent outcrops of bedrock and 10 to 50 percent mostly extremely stony Rockaway soils. Slopes range from 25 to 35 percent. The depth to bedrock varies from a few inches to 6 feet or more within a very short horizontal distance. Most of the area is shallow over bedrock. Granitic gneiss is the dominant kind of bedrock. On Green Pond Mountain red quartzite and conglomerate bedrock are common.

This mapping unit has such a high proportion of Rock outcrop and is so steep and so extremely stony that it is not suited to farming or to pasture. It is poorly suited to trees and to community development. Capability unit VIIIs-23.

Turbotville Series

The Turbotville series consists of deep, nearly level to gently sloping, somewhat poorly drained soils in waterways, in depressions on broad nearly level areas, and on terraces in the major valleys of the southwestern part of the county. These soils have a moderately developed fragipan. They formed in glacial till or stream deposits that were derived mainly from granitic material that contains a small amount of other rocks, including limestone. They are underlain by material weathered mostly from limestone bedrock, but in places there is a small amount of gneiss and other material. Granitic coarse fragments decrease with increasing depth. Some angular or rounded granitic gravel, cobbles, and stones are in the upper part of the soils.

In a representative profile the surface layer is dark-brown loam about 3 inches thick. The subsurface layer is yellowish-brown loam about 5 inches thick. The upper part of the subsoil is mottled, strong-brown heavy loam about 12 inches thick. The middle part of the subsoil is an extremely firm fragipan of variegated strong-brown, light yellowish-brown, and light-gray loam about 16 inches thick. The lower part of the subsoil is about 14 inches of strong-brown and brown loam. The substratum, between depths of 50 and 96 inches, is strong-brown and yellowish-brown gravelly fine sandy loam. Limestone bedrock is at a depth of 96 inches.

Permeability is moderate above the fragipan and slow in the fragipan. The available water capacity is moderate. In their natural condition these soils are wet during winter and early in spring. Depth to the seasonal high water table is about ½ foot to 1½ feet. In places after heavy rains, water ponds on these soils for several days. The fragipan restricts penetration of roots, and water stored below the fragipan is generally not available for use by plants.

Wetness restricts the choice of crops and the timing of farming practices on Turbotville soils. The native vegetation is pin oak, elm, and maple. If this soil is used for improved pasture and cultivated crops, improvement of drainage is necessary. Drainage diversions, interceptor drains, and spot drainage are effective. A seasonal high water table and lateral seepage of water on top of the fragipan are the main limitations for community development. In addition, the possible presence of open-jointed fractured limestone bedrock is a pollution hazard for onsite disposal of sewage.

Representative profile of Turbotville loam, 3 to 8 percent slopes, in a wooded area, 2,000 feet south of West Morris Regional High School and 2,000 feet east of Bartley Road:

A1—0 to 3 inches, dark-brown (10YR 4/3) loam; weak, fine, granular structure; very friable; many roots; 5 percent angular pebbles and cobbles, less than 1 percent stones, mainly granitic, and a few fragments of sandstone and quartzite; medium acid; gradual, wavy boundary. 1 to 3 inches thick.

A2—3 to 8 inches, yellowish-brown (10YR 5/8) loam; weak, medium, subangular blocky structure; friable; common roots; 5 percent pebbles, cobbles, and stones, mainly granitic, and a few fragments of sandstone, quartzite, and weathered limestone; medium acid; gradual, wavy boundary. 0 to 8 inches thick.

B2t—8 to 20 inches, strong-brown (7.5YR 5/6) heavy loam; few, fine, distinct, light-gray (10YR 7/2) mottles and few, fine, faint, strong-brown (7.5YR 5/8) mottles; moderate, medium, subangular blocky structure; friable; common roots in upper part, fewer with increasing depth; patchy clay films on faces of some peds redder than ped matrix; bridges between sand grains; 8 percent pebbles, cobbles, and stones, mainly granitic; fragments of limestone increase with increasing depth; medium acid; clear, wavy boundary. 10 to 26 inches thick.

Bx—20 to 36 inches, variegated strong-brown (7.5YR 5/8), light yellowish-brown (10YR 6/4), and light-gray (10YR 7/2) loam; weak, very coarse, prismatic structure; extremely firm; patchy clay films on faces of peds but very thick glossy coatings in pores; 8 percent pebbles, cobbles, and stones, mainly granitic but also a significant amount of weathered fragments of limestone; medium acid; gradual, wavy boundary. 10 to 30 inches thick.

B3—36 to 50 inches, strong-brown (7.5YR 5/8) and brown (7.5YR 5/4) light loam; massive; friable; 12 percent angular pebbles and cobbles, mostly granitic material, more limestone in the lower part; neutral; clear, wavy boundary. 0 to 24 inches thick.

IIC—50 to 96 inches, strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/6) gravelly fine sandy loam; massive; friable; 15 percent angular pebbles of limestone; mildly alkaline; abrupt, wavy boundary. 10 to 50 inches thick.

R—96 inches, thinly bedded, hard, impure, gray limestone bedrock.

The solum ranges from 40 to 60 inches in thickness. Depth to the fragipan ranges from 20 to 36 inches, and depth to bedrock is 5 to 8 feet or more. In most places the contact of the granitic gneiss drift in the upper part of the profile with the weathered limestone in the lower part of the profile is ill defined. In some places where the drift is very thin, a major part of the solum consists of material formed in material weathered from limestone. In other places the upper material is so thick that the solum includes material weathered from limestone. The content of angular pebbles and cobbles ranges from 5 to 20 percent, and scattered stones are in some places. In areas that are not limed, reaction is medium acid near the surface and neutral to mildly alkaline in the lower part. In areas that are limed, reaction is less acid near the surface.

The A horizon is 10YR in hue, 3 or 4 in value, and 2 to 3 in chroma.

The matrix of the B horizon is 4 or 5 in value and 6 to 8 in chroma. High-chroma mottles are 5YR or 7.5YR in hue, 5 or 6 in value, and 6 to 8 in chroma. Low-chroma mottles are 7.5YR or 10YR in hue, 6 to 7 in value, and 1 to 3 in chroma. Depth to mottles ranges from 10 to 18 inches. This horizon ranges from heavy loam to clay loam or silty clay loam. In most places it has moderate, medium, subangular blocky structure above the fragipan and weak, very coarse, prismatic; weak, very thick, platy; or weak, very coarse, prismatic with massive interiors in the fragipan. The B horizon ranges from friable above the fragipan to firm or extremely firm in the fragipan. The coarse fragments range from almost completely granitic gneiss in the upper part to largely limestone chips in the lower part.

The C horizon has value of 4 or 5 and chroma of 6 to 8. In some places isolated spots or speckles of high chroma are in a lower chroma matrix. These bright spots are small chips of highly weathered limestone. This horizon is loam to sandy loam and their gravelly analogs.

Turbotville soils are associated with Washington, Bartley, Cokesbury, and Edneyville soils. They have low-chroma mottles, whereas Washington and Edneyville soils are not mottled. Turbotville soils do not have the low-chroma matrix horizon that is common in Cokesbury soils. They have low-chroma mottles nearer to the surface than Bartley soils.

Turbotville loam, 0 to 3 percent slopes (TuA).—This nearly level soil is in swales that cross terraces and at the margins of terraces that extend along the base of valley side slopes. Included in mapping are small areas of Cokesbury and Bartley soils.

The dominant properties that affect the use of this nearly level soil are slow runoff; its low position on the landscape, where it receives drainage from surrounding higher areas; and a water table that is locally perched on the slowly permeable fragipan.

This soil is used for pasture, hay, cultivated crops, and woodland. If it is used for intensive cultivation or improved pasture, improvement of drainage is necessary. Drainage diversions, subsurface interceptor drains, and spot drainage are effective in helping to improve the soil for intensive farming. Poor drainage limits the use of this soil for community development. Capability unit IIw-71.

Turbotville loam, 3 to 8 percent slopes (TuB).—This soil has the profile described as representative of the series. Included in mapping are small areas of Bartley, Edneyville, and Washington soils and some areas of stony or bouldery soils. This soil is in small, narrow waterways or elongated areas at the base of steeper slopes within large areas of better drained soils. It is generally managed along with areas of surrounding soils.

This gently sloping soil has lateral seepage on top of the fragipan and a seasonally perched water table. The hazard of erosion is moderate.

In areas that are not drained, pasture, hay, and woodland are common uses. For intensive cultivation, improvement of drainage is necessary. Using drainage diversions, subsurface interceptor drains, and spot drainage are suitable practices. In addition, a crop rotation, stripcropping, and diversions help to control erosion. Poor drainage and susceptibility to erosion limit the use of this soil for community development. Establishing a vegetative cover early during development, helps to reduce erosion. Capability unit IIe-71.

Urban Land

Urban land consists mostly of areas that are either paved or built upon. The soils in the remaining open spaces have been reworked to the extent that the original profile cannot be recognized. The characteristics of the material are variable.

Areas of Urban land are in community development. They are not suited to other purposes.

Urban land (Ua).—This mapping unit is in areas that are mostly well-drained, deep sandy, gravelly, or stony material of assorted glacial deposits. The areas are on uplands that mostly range from gently sloping to strongly sloping. The surface has been smoothed and in most places leveled. Included in mapping are areas of moderately steep soils and small areas of undisturbed Rockaway, Hibernia, Riverhead, and Boonton soils and the Ellington loamy subsoil variant. Not assigned to a capability unit.

Urban land, wet (Ub).—This mapping unit is in areas that are mostly poorly drained to very poorly drained silty and clayey soils. These areas are on low positions in the landscape and are nearly level. They have slow permeability and are shallow over a seasonal high water table. Included in mapping were small undisturbed areas of Whippany and Parsippany soils. Most of this mapping unit results from cut and fill operations associated with site preparation to achieve slightly elevated areas of better drained soil. Not assigned to a capability unit.

Urban land-Edneyville complex (Ue).—This complex consists of well-drained gravelly and loamy soils. Slopes range from 3 to 25 percent but are commonly 8 to 15 percent. The depth to bedrock is variable, depending on the amount of cut or fill, but ranges from 1 foot or 2 feet in deep cuts to more than 10 feet in other areas.

This complex is about 45 percent cut and fill land and 40 percent Edneyville soils. The soils are in a complex pattern, and it is impractical to map them separately. Making up the remaining percentage are Parker and other soils. In most places the soil or soil material is 15 to 20 percent angular pebbles, but in deep cuts angular coarse fragments as large as stones are more prevalent.

Permeability is moderate, and the available water capacity is moderate or low. Runoff is moderate to rapid, and the hazard of erosion is moderate to moderately severe. Not assigned to a capability unit.

Urban land-Haledon complex (Uh).—This complex consists of somewhat poorly drained and well-drained soils that have a high proportion of silt and fine sand. Slopes are commonly 3 to 8 percent but range to as much as 15 percent in a few areas. The soil material is more or less gravelly and cobbly glacial deposits of material derived mainly from red and brown shale and sandstone, traprock, and granitic gneiss. The depth to and the kind of bedrock are variable because of the thickness of the glacial deposits. Fractured red shale and basalt are extensive.

This complex is about 40 percent cut and fill land and a nearly equal percentage of Haledon soils. About 20 percent is Boonton, Holyoke, and other soils.

Depth to the water table is generally more than 10 feet. In areas where the fragipan has not been removed, a seasonally perched water table is on top of the fragipan within a depth of 2 feet. Permeability is slow to very slow in the fragipan. If this complex is used for community development, lateral seepage to foundations and to the surface on steeper slopes and in excavations is likely. Runoff is moderate to rapid, depending on slope. The hazard of erosion is moderate to severe, depending on slope. Not assigned to a capability unit.

Urban land-Neshaminy complex (Uk).—This complex consists of well-drained, gently sloping stony soils. Slopes commonly range from 3 to 8 percent. The soil material is mainly weathered traprock and some small thin fragments of brown shale and sandstone. Depth to bedrock is variable, depending on the amount of excavation or fill, but ranges from 1 foot to more than 10 feet.

This complex is about 40 percent Neshaminy soils and 40 percent soils that have been disturbed by the activities of man to the extent that the original soil profile no longer remains. The soils occur in a complex pattern, and they cannot be mapped separately. Most areas also include small areas of more sloping Neshaminy soils, soils that are similar to this Neshaminy soil but have a mottled subsoil, Penn soils, and Ellington loamy subsoil variants.

This complex is deep over a water table and has moderate permeability, rapid runoff, moderate to severe hazard of erosion, and high available water capacity. Practices are needed to help control runoff and erosion, particularly on deep cuts. Suitable practices include constructing diversions, seeding with adapted grasses to help control erosion, and constructing retaining walls to stabilize deep cuts. Not assigned to a capability unit.

Urban land-Penn complex (Um).—This complex consists of well-drained soils that are underlain by red shale bedrock. It is near the bottom of slopes of the Watchung Mountains. Slopes commonly range from 0 to 10 percent. The soil material is residuum weathered from the underlying shale bedrock.

This complex is about 40 percent cut and fill land and 40 percent Penn soils. The soils are in a complex pattern and cannot be mapped separately. Making up the rest of the complex are small areas of Klinesville and Reaville soils.

On the sloping soils rapid runoff, a moderate hazard of erosion, and a moderate to low available water capacity are the major limitations. In construction areas, establishment of grass cover and diversion of long slopes by use of diversions or streets are beneficial in controlling runoff and erosion. Not assigned to a capability unit.

Urban land-Preakness complex (Un).—This complex consists of poorly drained, nearly level gravelly and sandy soils. The soil material is loose, relatively unweathered, stratified and sorted sandy and gravelly glacial outwash.

This complex is about 50 percent soils that have been disturbed by the activities of man to the extent that the original profile no longer remains and 40 percent Preakness soils. These soils occur in a complex pattern, and they cannot be mapped separately. Making up the remaining 10 percent are mainly Pompton and Riverhead soils.

Under natural drainage conditions the water table is at or near the surface for long periods during fall, winter, and spring. This complex is subject to flooding for long periods. In many places depth to the water table is increased, and the hazard of flooding is reduced by improved drainage or filling of low areas. Determination of the kind and degree of limitations to use of this complex requires onsite investigation. Not assigned to a capability unit.

Urban land-Riverhead complex (Up).—This complex consists of well-drained, nearly level to strongly sloping sandy and gravelly soils. It is mainly on undulating outwash terraces and plains in valleys, and in basins within and near the granitic highlands. Most areas are within the valleys of the Rockaway and Musconetcong River and in the basin formerly occupied by glacial Lake Passaic in the vicinity of Pompton Plains. Slopes range from 0 to 20 percent but are typically 5 to 12 percent. The underlying material is loose, unweathered, stratified and sorted sand and gravel outwash, mostly of granitic material that contains some shale, sandstone, quartzite, and conglomerate. Coarse fragments are mainly gravel and a few cobbles, but in places there are stones and boulders. Depth to a seasonally high water table is generally more than 10 feet.

This complex is about 55 percent soils that have been disturbed by man to the extent that the original profile no longer remains and 35 percent Riverhead soils. Making up the remaining percentage are areas of Otisville and Pompton soils.

Permeability is rapid, and runoff is moderate. If this complex is used for community development, practices are needed to control runoff and erosion. Using a grass cover and diversions in critical areas are suitable practices. Not assigned to a capability unit.

Urban land-Rockaway complex, gently sloping and sloping (UrC).—This complex consists of well-drained, gently sloping or sloping gravelly sandy loam soils. It is mainly in upland areas of intensive residential or industrial development in the vicinity of Rockaway, Dover, and Boonton. Slopes range from 0 to 15 percent.

The soil material is cobbly and stony glacial till that is mainly granitic material that contains a small amount of various other kinds of rock.

This complex is about 50 percent soils that have been disturbed by man to the extent that the original profile no longer remains and 40 percent Rockaway soils. The soils are in a complex pattern and it is not practical to map them separately. Making up the remaining percentage are small areas of Netcong and Hibernia soils.

This complex is generally deep over a water table, has rapid runoff and a moderate hazard of erosion, and is likely to have lateral seepage of water on top of the fragipan. In places where excavation has exposed the fragipan, seepage of water to the surface on top of the fragipan is common and causes unstable slopes and a hazard of erosion. Moderate measures are needed to control erosion and runoff. Suitable practices include using diversions, interceptor drains, and a grass cover. Not assigned to a capability unit.

Urban land-Rockaway complex, moderately steep (UrD).—This complex is in areas of steep, well-drained gravelly or stony sandy loam soils. It is in upland areas of residential developments. Slopes range from 15 to 25 percent. The soil material is cobbly and stony glacial till that is mainly granitic gneiss.

This complex is about 50 percent soils that have been disturbed by man to the extent that the original profile no longer remains and 40 percent Rockaway soils. These soils are in a complex pattern, and it is impractical to map them separately. Making up the remaining percentage are small areas of bouldery Rockaway soils, Netcong and Hibernia soils, or areas of bedrock outcrop. Most areas have been cut and filled for use as construction sites. Not assigned to a capability unit.

Urban land-Whippany complex (Uw).—This complex consists of somewhat poorly drained, nearly level or gently sloping clayey soils. It is in areas where developments extend into the bottom of the basin formerly occupied by glacial Lake Passaic.

This complex is about 40 percent fill land and 40 percent Whippany soils in a complex pattern; it is impractical to map them separately. Making up the remaining percentage are small areas of Parsippany, Haledon, and Boonton soils.

This complex has a water table near the surface during most of winter and spring. Permeability and runoff are slow. Occasional flooding is a hazard. In most places natural drainage has been improved by regrading the surface and constructing ditches. In many areas it is difficult to locate an adequate outlet for improved drainage because of the low position of the soils. Not assigned to a capability unit.

Washington Series

The Washington series consists of deep, nearly level to gently sloping, well-drained soils. These soils are on terraces within the major valleys of the Musconetcong River and the South Branch and North Branch of the Raritan River. They are well above the normal flood level. They formed mainly in weathered glacial till or fluvial deposits that consist of gneiss, limestone, and other rock fragments. They are underlain by material weathered from limestone and in places formed partly in this material. These soils contain gravel and cobbles.

In a representative profile the surface layer is dark-brown loam about 7 inches thick. The upper part of the subsoil is yellowish-brown loam about 13 inches thick, the middle part is yellowish-brown clay loam about 13 inches thick, and the lower part is yellowish-brown silt loam about 8 inches thick. The substratum, between depths of 41 and 78 inches, is brownish-yellow and strong-brown silt loam that gradually increases in content of limestone fragments. Hard limestone bedrock is at a depth of 78 inches.

Permeability is moderate, and available water capacity is high. Natural fertility is high. These soils have good workability, stability, and compaction characteristics.

Washington soils are well suited to general and specialized crops and have few limitations for sustained use. They also are well suited to community development. Open-jointed and fractured limestone bedrock, generally at a depth of 6 to 10 feet, causes a pollution hazard for onsite disposal of sewage.

Representative profile of Washington loam, 0 to 8 percent slopes, in a cultivated field, 660 yards southwest of the town of Long Valley, 300 yards southeast of County route 513:

Ap—0 to 7 inches, dark-brown (10YR 4/3) loam; moderate, coarse, granular and weak, fine, subangular blocky structure; friable; many fine roots; most sand grains and gravel are coated and stained with dark-brown (10YR 4/3) organic matter; 5 percent angular and subrounded pebbles of mixed lithology, but dominantly granitic and weathered limestone; medium acid; abrupt, smooth boundary. 6 to 10 inches thick.

B1—7 to 20 inches, yellowish-brown (10YR 5/8) heavy loam; moderate, medium and coarse, subangular blocky structure; friable; many fine roots in the upper 4 to 6 inches and common roots below; many large pores; dark-brown coatings (10YR 4/3) of material washed from the Ap horizon in pores and and on ped faces; 5 percent angular to rounded pebbles of mixed lithology, but mostly granitic material and limestone chips; medium acid; gradual, wavy boundary. 0 to 15 inches thick.

B2t—20 to 33 inches, yellowish-brown (10YR 5/6) clay loam; weak, very coarse, prismatic structure parting to strong, coarse, subangular blocky; friable; common fine roots; many large pores; patchy, very distinct, glossy, slightly redder clay films on some prism faces; 10 percent angular to rounded pebbles, mostly granitic but containing more limestone chips than B1 horizon; very small quantities of fragments of various other rocks; neutral; gradual, irregular boundary. 8 to 22 inches thick.

B3—33 to 41 inches, yellowish-brown (10YR 5/8) heavy silt loam; very weak, coarse, prismatic structure parting to moderate, medium and coarse, subangular blocky; friable; some prism faces are coated with small patches of clay films; 10 percent subangular granitic pebbles and angular limestone chips in nearly equal amounts; neutral; clear, wavy boundary. 5 to 14 inches thick.

IIC—41 to 78 inches, brownish-yellow (10YR 6/8) and strong-brown (7.5YR 5/6) silt loam; massive; friable; few roots; 10 percent coarse fragments of limestone chips in the upper part gradually increasing in amount with increasing depth to 25 percent at a depth of 70 inches; neutral; abrupt, wavy boundary. 12 to 48 inches thick.

IIR—78 inches, thin, bedded, fractured, impure limestone bedrock.

The solum ranges from 40 to 60 inches in thickness. Depth to bedrock is generally more than 6 feet. In most places hue is 10YR throughout but ranges to 7.5YR in the B horizon. These soils are not mottled but do have color variations associated with small chips of weathered limestone or small granitic pebbles that have value of 6 to 8 and chroma of 4 to 8. The content of coarse fragments is 5 to 25 percent. In most places the coarse fragments are almost completely granitic in the upper part of the profile, and they gradually change to weathered limestone chips in the lower part. Reaction ranges from medium acid to neutral and generally becomes less acid with increasing depth. In areas that have been limed heavily, reaction is less acid throughout. The B horizon formed mostly in material weathered from glacial till or fluvial material but in places extends into the underlying material weathered from limestone. The boundary between the glacial or fluvial deposits of mostly granitic material and the material weathered from limestone is abrupt in some places but in others is so gradual that no sharp boundary can be identified.

The A horizon is 4 in value and 2 to 4 in chroma. In many places a 2- to 3-inch zone of weak platy structure is above and below the contact of the Ap horizon with the B horizon. This zone is generally firm, but most of the Ap horizon is very friable or friable.

The B horizon has value of 5 or 6 and chroma of 6 to 8. In most places this horizon is heavy loam or clay loam, but it ranges to heavy silt loam and silty clay loam.

The C horizon is 5 or 6 in value and 6 to 8 in chroma. This horizon is loam or silt loam, and the content of weathered limestone chips increases with increasing depth.

The underlying bedrock is not cavernous but has open joints and fractures.

Washington soils are associated with Bartley, Turbotville, Riverhead, Riverhead variant, Edneyville, and Pattenburg soils. They do not have the fragipan that is common in Bartley and Turbotville soils. Washington soils contain more clay than Riverhead soils and the Riverhead variant. They are much less acid than Edneyville soils and do not have the high content of gravel that is common in Pattenburg soils.

Washington loam, 0 to 8 percent slopes (WaB).—This soil is on terraces in major valleys. Included in mapping are small areas of Bartley, Edneyville, and Turbotville soils and some Washington soils that have slopes of more than 8 percent. Also included along Gladstone Brook are some small areas of a soil that formed in material weathered from shale and small areas of Pattenburg soils.

This nearly level to gently sloping soil is loamy throughout and has a low proportion of coarse fragments, moderate permeability, high available water capacity, and a moderate hazard of erosion.

This soil is well suited to crops, pasture, woodland, and community development. Conservation practices commonly used include a crop rotation, contour cultivation, and stripcropping on longer slopes. High-value crops are commonly irrigated. Capability unit IIe-54.

Whippany Series

The Whippany series consists of deep, nearly level to gently sloping, somewhat poorly drained soils. These soils are on slight elevations or in gently sloping peripheral areas within the basin formerly occupied by glacial Lake Passaic. The soils formed in thick deposits of lacustrine sediment derived from red and brown shale and sandstone, basalt, and granitic rock. The sediment is so thick that the depth to and kind of bedrock are generally unknown, but it includes red and brown shale, sandstone, and basalt.

In a representative profile the surface layer is dark grayish-brown silt loam about 9 inches thick. The upper 18 inches of the subsoil is strong-brown heavy silt loam and silty clay loam mottled with light brownish gray, pale brown, and dark yellowish brown. The lower 13 inches of the subsoil is dark-brown silty clay loam mottled with light brownish gray. Between depths of 40 and 60 inches, the substratum is mottled, reddish-brown silt loam.

Permeability is slow, and available water capacity is high. These soils have poor workability and good to poor stability and compaction characteristics because of the high content of silt and clay. The water table is at a depth of ½ foot to 1½ feet late in winter, early in spring, and after heavy rains. During summer it drops to a depth of 3 or 4 feet. In places nearly level Whippany soils are ponded for a brief period after heavy rain.

Whippany soils support swamp maple, sweetgum, pin oak, elm, hickory, and swamp white oak. Unless drained, the soils are used for water-tolerant hay and pasture. Intensive cultivation requires improved drainage.

Representative profile of Whippany silt loam, 0 to 3 percent slopes, in a hayfield, 100 feet east of Pleasant Plains Road, one-fourth mile south of right-angle turn, 50 feet south of field boundary, in Harding Township:

Ap—0 to 9 inches, dark grayish-brown (10YR 4/2) silt loam; moderate, medium, granular structure; very friable; many, fine, fibrous roots; nearly all grains stained; slightly acid; abrupt, smooth boundary. 6 to 10 inches thick.

B1—9 to 15 inches, strong-brown (7.5YR 5/6) heavy silt loam; many, coarse, prominent, light brownish-gray (10YR 6/2) and pale-brown (10YR 6/3) mottles; moderate, medium, subangular blocky structure; firm, plastic, sticky; many, fine, fibrous roots; few patches of uncoated fine sand and silt grains near top diminish clay films on ped faces; medium acid; gradual, wavy boundary. 0 to 7 inches thick. gradual, wavy boundary. 0 to 7 inches thick.

B21t—15 to 27 inches, strong-brown (7.5YR 5/6) silty clay loam; common, coarse, distinct, dark yellowish-brown (10YR 4/4) and light brownish-gray (10YR 6/2) mottles; moderate, medium, subangular blocky structure; vertically oriented pale-colored streaks 6 to 24 inches apart suggest very weak, prismatic structure; firm, very plastic, sticky; fine fibrous roots; discontinuous semiglossy clay films on ped faces; slightly acid; gradual, wavy boundary. 10 to 20 inches thick.

B22t—27 to 40 inches, dark-brown (7.5YR 4/4) silty clay loam; few, coarse, distinct, light brownish-gray (10YR 6/2) mottles; moderate, medium, subangular blocky structure; widely spaced, vertically oriented, pale-colored streaks; firm, plastic, sticky; patchy dull clay films on most ped faces; slightly acid; clear, wavy boundary. 10 to 15 inches thick.

C—40 to 60 inches, reddish-brown (5YR 4/4) silt loam; few, coarse, distinct, pale-brown (10YR 6/3) and pinkish-gray (7.5YR 6/2) mottles; mottles are generally horizontally oriented and associated with stratification; massive; friable; neutral.

The solum ranges from 30 to 50 inches in thickness. Coarse fragments are generally lacking throughout the solum, in places the solum is as much as 5 percent gravel and cobbles. Below a depth of 40 inches, in places, gravel and cobbles make up as much as 30 percent of the material. Matrix color in the upper part of the profile is commonly 10YR or 7.5YR; in the lower part it ranges to hue of 5YR, value of 4 to 6, and chroma of 3 to 6. Low-chroma mottles

are pronounced in the upper part of the B horizon, but they decrease with increasing depth. These low-chroma mottles in places are 2.5Y in hue and 3 to 6 in value. Reaction is medium acid to slightly acid near the surface and slightly acid or neutral in the lower part of the B horizon and in the C horizon.

The B horizon ranges from heavy silt loam to clay and has moderate to strong, medium to coarse, subangular blocky structure. In some places it has angular blocky or weak platy structure. In other places, it has some widely spaced (1 foot to 3 feet), vertically oriented cracks or streaks that suggest weak prismatic structure.

The C horizon is stratified sand to clay in lenses or varves. In some places fine-textured material extends below a depth of 40 inches, either as dominant strata or included lenses. In others loamy-textured strata are dominant below a depth of 40 inches.

Whippany soils are associated with Parsippany, Pompton, Ellington, Haledon, and Boonton soils. They do not have the gray B horizon that is common in Parsippany soils. They are not so coarse textured as Pompton, Ellington, Riverhead, Haledon, and Boonton soils.

Whippany silt loam, 0 to 3 percent slopes (WhA).—This soil has the profile described as representative of the series. Included in mapping are small areas of Parsippany and Pompton soils. Also included are some areas of soils in which the surface layer is silty clay loam.

This soil has a fine textured or moderately fine textured subsoil, is slowly permeable, and has a perched water table at a depth of ½ foot to 1½ feet for brief periods in winter, early in spring, and after heavy rains.

Cleared areas are used mainly for pasture and hay. For cultivated crops, improved drainage is necessary. Among the suitable practices is surface drainage, such as bedding and ditching. This soil is a natural site for dug ponds and impoundments. Capability unit IIIw-70.

Whippany silt loam, 3 to 8 percent slopes (WhB).—This soil has a profile similar to the one described as representative of the series, but in places the surface layer is silty clay loam. Included in mapping are small areas of Parsippany soils.

This soil has a moderate hazard of erosion. Constructing diversions to intercept seepage and runoff received from adjoining higher areas improves drainage and reduces erosion. Bedding systems are effective in draining excess surface water. If drained, this soil is suited to corn, hay, and pasture. Poor drainage and the hazard of erosion are limitations for community development. Capability unit IIIw-70.

Whippany silt loam, sandy loam substratum, 0 to 3 percent slopes (WlA).—This soil has a profile similar to the one described as representative of the series, but it contains thin strata of sandy loam above a depth of 40 inches and is dominantly sandy loam below that depth. Included in mapping are small areas of Parsippany and Pompton soils.

In its natural condition this soil is used for woodland. Cleared areas are generally used for pasture and hay. If the soil is used for corn, improved drainage is necessary. Suitable practices include deep peripheral drainage ditches and bedding systems. The soil is suitable for dug ponds and impoundments. Capability unit IIIw-70.

Whippany silt loam, sandy loam substratum, 3 to 8 percent slopes (WlB).—This soil has a profile similar to the one described as representative of the series, but it has thin strata of sandy loam above a depth of 40 inches and is dominantly sandy loam below that depth. Included in mapping are small areas of Parsippany and Boonton soils.

This soil has a moderate hazard of erosion. If this soil is farmed, drainage diversions are effective in intercepting seepage and runoff from adjoining higher areas to reduce the hazard of erosion. Where adequate outlets are available, peripheral drainage systems provide underdrainage. This soil is suited to corn, hay, and pasture. Capability unit IIIw-70.

Whitman Series

The Whitman series consists of deep, nearly level, very poorly drained stony and gravelly soils. These soils are in depressions and seepage areas within valleys and waterways. They have a well-developed fragipan. The soils formed in weathered glacial till and in most places have a thin mantle of alluvium from the adjacent soils.

In a representative profile the surface layer is black cobbly loam about 8 inches thick. The upper 12 inches of the subsoil is light brownish-gray gravelly sandy loam mottled with reddish brown. The lower 5 inches is a fragipan of grayish-brown, very firm, dense gravelly sandy loam. The upper 15 inches of the substratum is part of the fragipan and is gray, firm sandy loam. Below this, to a depth of 60 inches, the substratum is mottled, light brownish-gray, pale-brown, and grayish-brown, loose gravelly loamy sand. Characteristically, the soil material feels gritty because of a high proportion of medium and coarse sand, mostly of quartz and feldspar and a small amount of mica and dark-colored ferromagnesian minerals.

Permeability is slow in the fragipan, and runoff is slow or ponded in depressions and nearly level areas. The available water capacity is moderate. A perched water table is at or near the surface for long periods during winter and spring and after heavy or long rains. Stones and boulders are throughout the soil. Areas of these soils receive runoff and seepage water from the surrounding higher land.

Undisturbed areas of Whitman soils are woodland. A small acreage is cleared and used for pasture. If these soils are used for crops or pasture, improved drainage and removal of stones are necessary. Because of their low position on the landscape, these soils are natural sites for waterways, outlets, ponds, and reservoirs. The need for improved drainage and the presence of stones and boulders are limitations to use of these soils for community development.

Representative profile of Whitman cobbly loam in an area of Whitman very stony loam (0 to 3 percent slopes) 100 feet northwest of Wharton and Northern Railroad 100 yards south of Timberbrook Road, in Rockaway Township:

A1—0 to 8 inches, black (10YR 2/1) cobbly loam; moderate, fine, granular structure; friable, slightly sticky; many roots; high in organic matter; 20 percent stones, cobbles, and gravel; medium acid; abrupt, wavy boundary. 3 to 10 inches thick.

Bg—8 to 20 inches, light brownish-gray (10YR 6/2) gravelly sandy loam; few, fine, distinct , reddish-brown (5YR 4/3) mottles; weak, fine and medium, subangular blocky structure; friable; common, fine, fibrous roots; 20 percent gravel, cobbles, and stones; many pores partly filled with fines; medium acid; clear, wavy boundary. 5 to 16 inches thick.

Bx—20 to 25 inches, grayish-brown (10YR 5/2) gravelly sandy loam; massive; very firm and brittle; few fine roots; 30 percent stones, cobbles, and gravel; strongly acid; gradual, wavy boundary. 6 to 15 inches thick.

C1x—25 to 40 inches, gray (5Y 5/1) sandy loam; massive; firm; 10 percent gravel and cobbles; strongly acid; clear, wavy boundary. 6 to 24 inches thick.

C2—40 to 60 inches, mottled light brownish-gray (10YR 6/2), pale-brown (10YR 6/3), and grayish-brown (2.5Y 5/2) gravelly loamy sand; single grained; loose; 30 percent gravel, stones, and cobbles; strongly acid.

The solum ranges from 20 to 40 inches in thickness. Depth to the fragipan is 18 to 25 inches. The fragipan ranges from 10 to 36 inches in thickness, but in places it is restricted to the B horizon. Depth to bedrock is 10 feet or more. Coarse fragments make up 5 to 35 percent of the mass throughout. Stones and boulders are on the surface and throughout the soils. In areas that are not limed, reaction ranges from medium acid to very strongly acid throughout.

The A horizon ranges from black (10YR 2/1 or N 2/0) to very dark brown (10YR 2/2).

The B and C horizons have a matrix of 10YR to 5Y in hue, 4 to 6 in value, and 0 or 2 in chroma. These horizons are sandy loam, gravelly sandy loam, or gravelly loam above a depth of 30 inches and loamy sand or gravelly loamy sand below that depth. Mottles in hue of 5YR to 10YR, value of 4 to 6, and chroma of 3 to 8 are in most profiles and range from few to many and fine to coarse.

Whitman soils are associated with Ridgebury, Hibernia, and Carlisle soils. They are grayer than Ridgebury and Hibernia soils and do not have a deep organic deposit that is common in Carlisle soils.

Whitman very stony loam (Wm).—This soil is nearly level. Some areas have nearly equal proportions of stony loam and loam, and there are a few areas where one or the other is dominant. Included in mapping are small areas of more steeply sloping Whitman soils, Ridgebury soils, and shallow muck soils.

This soil has a high content of organic matter in the surface layer, contains stones and boulders throughout, has a seasonally high water table at or above the surface, has slow permeability, and is frequently ponded.

If this soil is used for intensive farming or community development, it requires improved drainage and removal of stones. Because of its low position on the landscape, outlets for subsurface drainage systems or ditches are difficult to obtain in many places. Where adequate outlets are available, this soil can be drained by tiling or by open ditches. Where seepage from adjoining higher areas is a hazard, interceptor drains are beneficial. Capability unit VIIs-45.

Use and Management of the Soils

In the following section, use and management of the soils is considered for wildlife, trees, crops, engineering, and community development.

Wildlife[2]

Morris County has abundant and varied wildlife that is enjoyed by residents and visitors throughout the year. The high populations of deer, rabbit, and songbirds can readily be observed from roads and rural residences. Pheasant are also found in farm areas and near areas that are regularly stocked. Many of the birds in the county help to control insect pests, and others consume large quantities of weed seeds. Such predators as skunk, fox, hawks, and owls, besides being an interesting part of the environment, help to keep small rodents under control.

The county's varied relief and fields in early stages of plant succession provide generally good wildlife habitat. The continuing reversion of open fields to brush and trees and urbanization are gradually reducing the amount and variety of quality wildlife habitat. Only a few large areas support wetland wildlife. Geese and duck are common on the lakes and ponds in the county, especially in fall and in spring. These lakes and ponds also provide fishing.

The wildlife population of any area depends on the availability of food, cover, and water in a suitable combination. Habitat for an individual bird or animal species or group of species is created, improved, and maintained by establishing and maintaining vegetation in the required combinations for food and cover. Soils vary in their suitability for the establishment and maintenance of quality wildlife habitat. Individual soils, unless the present condition has been altered by man's activities, react similarly throughout the area.

In table 2 the soils are rated as to their inherent limitations for the development, maintenance, and management of good habitat for wildlife. On soils rated *good,* habitat is generally easily created, improved, or maintained; there are few or no soil limitations in habitat management, and satisfactory results are well assured. On soils rated *fair,* habitat usually can be created, improved, or maintained, but the soils have moderate limitations that affect the creation, improvement, or maintenance of the habitat; a moderate intensity of management and fairly frequent attention may be required to assure satisfactory results. On soils rated *poor,* habitat can usually be created, improved, or maintained, but there are rather severe soil limitations; habitat management may be difficult, expensive, and require intensive effort, and satisfactory results are questionable. On soils rated *very poor,* it is impractical to create, improve, or maintain habitat because of the very severe soil limitations; unsatisfactory results are probable.

The ratings of the soils in table 2 for habitat valuable to the three general kinds of wildlife were derived by assigning weighted values, based on the relative importance to the group, to each of the previously rated habitat elements. Present land use and present vegetation are not considered in the ratings of soils for wildlife habitat. These are subject to change and, although they are important in detailed planning for wildlife,

[2] EUGENE WHITAKER, biologist, Soil Conservation Service, helped prepare this section.

there is no practical method of determining quality from a soil survey. The soil areas outlined on the soil map are rated without regard to their position or their relation to adjoining, or nearby, soil areas. The shape, size, or relation of an outlined area is not considered in its rating. The ability of wildlife to move from place to place is also disregarded. The rating is one of suitability of the soil for the stated kind of habitat, not a direct rating of the suitability of the soil for the species of wildlife.

Ratings are not made for Made land, sanitary land fill; Pits, sand and gravel; or the Urban land units, because the soil materials in these mapping units are so variable that ratings would not be reliable. Rock outcrop is not rated because it is nearly devoid of vegetation. These units represent about 12 percent of the county.

The elements of wildlife habitat considered in table 2 are described in the following paragraphs.

Grain and seed crops are domestic grains or seed-producing annual herbaceous plants that mainly produce food for wildlife in crop residue and food-patch plantings. Examples are corn, soybeans, barley, wheat, millet, and sunflower.

Grasses and legumes are domestic grasses and herbaceous legumes that are commonly planted for forage or control of erosion but that also provide habitat for wildlife. They may also be planted to provide nesting and cover as well as food. Examples are alfalfa, clover, tall fescue, orchardgrass, reed canarygrass, lovegrass, and redtop.

Wild herbaceous upland plants are native or introduced grasses, legumes, and weeds that generally become established naturally or they can be planted; these plants are used by wildlife for food and cover. They include panicgrasses, wildrye, foxtail, barnyardgrass, partridgepea, beggartick, lespedeza, pokeweed, dandelion, and other native forbs, commonly referred to as weeds.

Hardwood and coniferous trees include native or introduced trees, shrubs, and woody vines that provide cover or food for wildlife. The food consists of fruit, nuts, buds, catkins, twigs, or foliage. On uplands the most common trees are oaks, beech, hickory, yellow-poplar, dogwood, ash, sassafras, black birch, white pine, hemlock, redcedar, Scotch pine, Norway spruce, and some small areas of pitch pine. The shrubs and vines of the uplands are low-bush blueberry, sumac, laurel, grapes, and spice bush. In the lowlands, the most common trees are pin, willow, and swamp oaks; beech; maple; sassafras; birch; tamarack; and hemlock. The most common shrubs and vines of the lowlands are highbush blueberry, viburnum, elderberry, greenbrier, sweet pepperbush, and button bush. Autumn-olive, pyracantha, Amur honeysuckle, Scotch pine, white pine, and Norway spruce can be planted to provide cover or winter food.

Wetland food and cover plants are introduced and native plants that provide food and cover for duck, geese, sandpipers, muskrat, and other wetland wildlife. Most occur naturally, but some can be planted. Examples are wild millet, smartweed, bulrush, sedges, switchgrass, rice cutgrass, and cattails. Fast-maturing varieties of grain and seed crops (grain sorghum, Japanese millet, and buckwheat, for example) that can be planted during dry periods in summer to provide food in fall and in winter are also included.

Shallow-water developments are shallow impoundments, excavations, or a combination of both, that have water less than 5 feet deep over the majority of the area to provide habitat for wetland wildlife. Such developments are usually created by construction of dams or levees and have facilities built in to regulate the water level. They may be shallow excavations in swamp areas providing open water to permit fuller use of the area by wetland birds and animals.

The kinds of wildlife—openland, woodland, and wetland—considered in table 2 are discussed in the following paragraphs.

Openland wildlife are birds and mammals that normally frequent cropland, meadows, lawns, and nonforested areas overgrown with grasses, herbs, and shrubby growth. Examples are pheasant, woodchucks, mourning dove, red fox, cottontail rabbits, skunks, field sparrows, meadowlarks, and killdeer. One-quarter of the county's soils are naturally good for the development of habitat for openland wildlife. These are generally such soils as Washington, Bartley, Edneyville, and Netcong soils, which are well suited to crops. These soils are also usually good for urbanization. When abandoned for farming, the soils revert to brush and trees as do those soils rated fair for openland wildlife. These include Alluvial land and Parsippany soils that have impaired drainage and such somewhat stony soils as Hibernia stony loam, 3 to 15 percent slopes, on which it is difficult to establish annual vegetation. Soils rated poor for openland wildlife are mainly the sloping, rocky, or wet soils in the county, such as Ridgebury soils and the steeper Rockaway soils. The very poorly drained Carlisle and Adrian soils and the extremely droughty Otisville soils are very poorly suited to openland wildlife habitat development.

Woodland wildlife are birds and mammals commonly found in wooded areas, although they may also use open areas and may be dependent on disturbed areas of earlier successional species within the woods. Among these are white-tailed deer, ruffed grouse, squirrels, gray fox, thrushes, towhees, and vireos. Some species, such as woodcocks and raccoons, require wet wooded areas. Most of Morris County is good or fair for woodland wildlife. The soils rated *good* include the deeper soils that have high or moderate available water capacity, such as Annandale, Edneyville, Neshaminy, and Penn soils. The soils rated *fair* include the stony and wet soils, such as Cokesbury soils. The dry, steep Parker soils and the steep Klinesville soils are rated *poor*. The very wet, swampy Carlisle and Adrian soils are rated *very poor* for woodland wildlife habitat.

Wetland wildlife are birds and animals commonly found in swamps and marshy areas. Examples are duck, heron, snipe, shore birds, mink, muskrat, and frogs. Most of the soils in Morris County have slopes of more than 3 percent and are rated *very poor* for the development of habitat for wetland wildlife. There are

TABLE 2.—*Suitability of the soils for elements of wildlife habitat and for kinds of wildlife*

Soil series and map symbols	Elements of wildlife habitat						Kinds of wildlife		
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood and coniferous trees	Wetland food and cover plants	Shallow-water developments	Openland	Woodland	Wetland
Adrian: Ad	Very poor	Very poor	Very poor	Very poor	Good	Good	Very poor	Very poor	Good.
Alluvial land:									
Ae	Poor	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
Am	Very poor	Poor	Poor	Poor	Good	Good	Poor	Poor	Good.
Annandale: AnB, AnC	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
Bartley:									
BaA	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
BaB, BbC	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
Biddeford: Bd	Very poor	Poor	Poor	Poor	Good	Good	Poor	Poor	Good.
Boonton:									
BoB, BoC	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
BpC	Very poor	Very poor	Good	Good	Very poor	Very poor	Poor	Good	Very poor.
Califon:									
CaA	Fair	Good	Good	Good	Fair	Fair	Good	Good	Fair.
CaB, CaC, CbB	Fair	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
CcB, CcC	Very poor	Poor	Good	Good	Poor	Very poor	Poor	Good	Very poor.
Califon variant: CdB	Fair	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Carlisle: Cm	Very poor	Very poor	Very poor	Very poor	Good	Good	Very poor	Very poor	Good.
Cokesbury:									
CoA	Poor	Fair	Fair	Fair	Good	Fair	Fair	Fair	Fair.
CoB	Poor	Fair	Fair	Fair	Poor	Very poor	Fair	Fair	Very poor.
CsB	Very poor	Very poor	Fair	Fair	Poor	Very poor	Poor	Fair	Very poor.
Edneyville:									
EdB, EdC	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
EdD	Poor	Fair	Good	Good	Very poor	Very poor	Fair	Good	Very poor.
Ellington variant:									
ElB, ElC	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
ElD	Poor	Fair	Good	Good	Very poor	Very poor	Fair	Good	Very poor.
Haledon: HaB, HaC	Fair	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Hibernia:									
HbC	Poor	Fair	Good	Good	Very poor	Very poor	Fair	Good	Very poor.
HlD	Very poor	Poor	Good	Good	Very poor	Very poor	Poor	Good	Very poor.
Holyoke: HoC, HrE. Rock outcrop part of HrE too variable to rate.	Poor	Poor	Fair	Fair	Very poor	Very poor	Poor	Fair	Very poor.
Klinesville: KlE	Very poor	Poor	Fair	Poor	Very poor	Very poor	Poor	Poor	Very poor.
Made land, sanitary land fill: Ma. Too variable to rate.									
Minoa:									
MlA	Fair	Good	Good	Good	Fair	Fair	Good	Good	Fair.
MlB	Fair	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Muck: Ms, Mu	Very poor	Very poor	Very poor	Very poor	Good	Good	Very poor	Very poor	Good.

TABLE 2.—*Suitability of the soils for elements of wildlife habitat and for kinds of wildlife*—Continued

Soil series and map symbols	Elements of wildlife habitat						Kinds of wildlife		
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood and coniferous trees	Wetland food and cover plants	Shallow-water developments	Openland	Woodland	Wetland
Neshaminy: NeB, NeC	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
NfD	Very poor	Poor	Good	Good	Very poor	Very poor	Poor	Good	Very poor.
Netcong: NtB, NtC	Fair	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Otisville: OtC, OtD	Poor	Poor	Fair	Poor	Very poor	Very poor	Poor	Poor	Very poor.
Parker: PaC	Poor	Fair	Fair	Poor	Poor	Very poor	Fair	Poor	Very poor.
PbD, PeC, PeD, PfE	Poor	Fair	Fair	Poor	Very poor	Very poor	Fair	Poor	Very poor.
Rock outcrop part of PfE too variable to rate.									
Parsippany: Ph, Pk	Poor	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
Pattenburg: PlB, PlC	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
Penn: PnB, PnC	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
PoD	Very poor	Fair	Good	Good	Very poor	Very poor	Fair	Good	Very poor.
Pits, sand and gravel: Ps. Too variable to rate.									
Pompton: PtA	Fair	Good	Good	Good	Fair	Poor	Good	Good	Poor.
PtB	Fair	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Preakness: PvA	Poor	Fair	Fair	Fair	Good	Poor	Fair	Fair	Fair.
Pw	Very poor	Poor	Poor	Poor	Good	Poor	Poor	Poor	Fair.
Reaville variant: ReB	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Ridgebury: RgA	Very poor	Poor	Fair	Fair	Good	Poor	Poor	Fair	Fair.
RlB	Very poor	Very poor	Fair	Fair	Poor	Very poor	Poor	Fair	Very poor.
Riverhead: RmA, RmB, RmC.	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
Riverhead variant: RnB.	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
Rockaway: RoB, RoC	Fair	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
RpC, RrD	Very poor	Poor	Good	Good	Very poor	Very poor	Poor	Good	Very poor.
RsC, RsD, RsE	Very poor	Poor	Good	Fair	Very poor	Very poor	Poor	Fair	Very poor.
Rock outcrop part of RsC, RsD, and RsE too variable to rate.									
Rock outcrop: Rt. Too variable to rate.									
RvF	Very poor	Very poor	Poor	Very poor	Very poor	Very poor	Very poor	Very poor	Very poor.

TABLE 2.—*Suitability of the soils for elements of wildlife habitat and for kinds of wildlife*—Continued

Soil series and map symbols	Elements of wildlife habitat						Kinds of wildlife		
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood and coniferous trees	Wetland food and cover plants	Shallow-water developments	Openland	Woodland	Wetland
Turbotville:									
TuA	Fair	Good	Good	Good	Fair	Poor	Good	Good	Poor.
TuB	Fair	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Urban land: Ua, Ub, Ue, Uh, Uk, Um, Un, Up, UrC, UrD, Uw. Too variable to rate.									
Washington: WaB	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Whippany:									
WhA, WlA	Fair	Good	Good	Good	Fair	Fair	Good	Good	Fair.
WhB, WlB	Fair	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Whitman: Wm	Very poor	Poor	Poor	Poor	Good	Fair	Poor	Poor	Fair.

small areas on some of these unsuitable soils where small backyard marshes could be impounded for esthetic purposes and to increase the diversity of ecological types on a property. The soils rated *good* include such nearly level, wet soils as Adrian, Biddeford, Carlisle, and Parsippany soils. Most of these soils presently support woody vegetation. The value of the soils in this group to wetland wildlife can readily be improved by the creation of small areas of open water and, in some instances, the establishment of higher producing food plants. The nearly level Califon, Cokesbury, and Minoa soils are rated *fair*. Most areas are now wooded and somewhat poorly drained or poorly drained. They have a slightly lower water table than other soils, and it is more difficult to develop wetland habitat on them.

Woodland[3]

About half of Morris County is wooded. Originally all of Morris County, except for marshes, was forested (*2*). Mixed hardwoods dominate throughout the county, except in some small isolated areas. In the isolated areas, hemlock trees grow on cool, moist sites, white pine on deep sandy soils, and tamarack in some of the swampy areas. Eastern redcedar invades abandoned fields.

During the 350 years of urban development, many changes have occurred in the woodland. Present conditions in much of the woodland reflect a history of farming on the rolling lands and repeated cutting on the steeper slopes. Repeated cutting is most evident in the northern part of the county, where iron mines were once prevalent. Here, there is much coppice growth because of heavy cutting of small diameter trees for fuelwood, mine props, and furnace poles. The forest composition was also changed significantly with the death of the American chestnut.

[3] RONALD J. SHEA, area forester, New Jersey Bureau of Forestry, helped prepare this section.

Many of the coppice stands contain desirable trees of good quality. Rapid urban development and high land values have forced a decline in the management of woodland for forest products. A limited number of loggers is available to harvest trees. High-quality species of oak, yellow-poplar, and black walnut are in demand and command a good stumpage value. Areas of mature quality stands are not extensive.

There will be extensive areas of woodland in the county for some time. Use of the woodland, for the most part, will be multiple. Some areas will protect reservoirs. Woodland is important habitat for many animals. Camping, hunting, fishing, hiking, skiing, picnicking, bird watching, and snowmobiling are important recreational activities that are chiefly centered in the woodland.

Capability Grouping

Some readers, particularly those who farm on a large scale, may find it practical to use and manage alike some of the different kinds of soil on their farm. These readers can make good use of the capability classification system, a grouping that shows in a general way the suitability of soils for most kinds of farming.

The grouping is based on limitations of soils when used for field crops, the risk of damage when they are farmed, and the way the soils respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suit-

ability and limitations for community development, trees, or engineering.

In the capability system, all kinds of soil are grouped at three levels: the class, the subclass, and the unit. The eight classes in the capability system and the subclasses and units in Morris County are described in the list that follows. The capability unit designation for each soil is shown in the Guide to Mapping Units.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I to VIII. The numerals indicate progressively greater limitations and narrower choices for practical use.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral; for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in some parts of the United States but not in Morris County, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, although they have other limitations that restrict their use largely to pasture, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol; for example, IIe-5 or IIIe-7. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

The capability unit numbers are assigned by geographic areas, so the unit numbers in this county are not consecutive.

The eight classes in the capability system, the subclasses, and the units in the county are described in the following list.

Class I. Soils have few limitations that restrict management or adapted plants that may be grown.
- Capability unit I-7.—Nearly level, deep, well-drained, gravelly, moderately coarse textured soils.

Class II. Soils have some limitations that reduce the choice of plants or require moderate conservation practices.

Subclass IIe. Soils that have a moderate risk of erosion unless protected.
- Capability unit IIe-5.—Gently sloping, deep, well drained or moderately well drained, gravelly, moderately coarse textured or medium-textured soils that have restricted permeability in the lower part of the subsoil.
- Capability unit IIe-7.—Gently sloping, deep, well-drained, gravelly, moderately coarse textured soils.
- Capability unit IIe-53.—Gently sloping, deep, well-drained soils that have a moderately fine textured subsoil and restricted permeability in the lower part of the subsoil.
- Capability unit IIe-54.—Gently sloping, deep, well-drained soils that have a moderately fine textured subsoil.
- Capability unit IIe-55.—Gently sloping, deep, well-drained, gravelly soils that have a moderately fine textured subsoil that has a high proportion of silt.
- Capability unit IIe-58.—Gently sloping, deep, well-drained, gravelly soils that have a medium-textured subsoil.
- Capability unit IIe-65.—Gently sloping, moderately deep, well-drained, shaly, medium-textured soils.
- Capability unit IIe-71.—Gently sloping, deep, moderately well drained or somewhat poorly drained soils that have a moderately fine textured and medium-textured subsoil.

Subclass IIw. Soils that have moderate limitations caused by excess water.
- Capability unit IIw-25.—Nearly level or gently sloping, deep, somewhat poorly drained, moderately coarse textured soils.
- Capability unit IIw-70.—Nearly level or gently sloping, deep, somewhat poorly drained, medium-textured soils.
- Capability unit IIw-71.—Nearly level, deep, moderately well drained or somewhat poorly drained, moderately fine textured soils.

Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Subclass IIIe. Soils that have a severe risk of erosion if they are cultivated and not protected.
- Capability unit IIIe-5.—Strongly sloping, deep, well drained or moderately well drained, gravelly soils that have a moderately coarse textured or medium-textured subsoil and restricted permeability in the lower part of the subsoil.
- Capability unit IIIe-7.—Strongly sloping, deep, well-drained, gravelly, moderately coarse textured soils.
- Capability unit IIIe-25.—Strongly sloping, deep, moderately well drained soils that have a moderately coarse textured subsoil.
- Capability unit IIIe-53.—Strongly sloping, deep, well-drained soils that have a moderately fine textured subsoil and a fragipan.

Capability unit IIIe-55.—Strongly sloping, deep, well-drained, gravelly soils that have a moderately fine textured subsoil that contains a high proportion of silt.

Capability unit IIIe-58.—Gently sloping and strongly sloping, deep, well-drained or excessively drained soils that have a gravelly, moderately coarse textured to moderately fine textured subsoil.

Capability unit IIIe-65.—Strongly sloping, moderately deep, well-drained, shaly, medium-textured soils.

Capability unit IIIe-71.—Strongly sloping, deep, moderately well drained or somewhat poorly drained, moderately fine textured soils.

Subclass IIIw. Soils that have severe limitations caused by excess water.

Capability unit IIIw-41.—Nearly level, very poorly drained, deep, organic soils that are underlain by coarse-textured to fine-textured mineral materials.

Capability unit IIIw-70.—Nearly level or gently sloping, deep, somewhat poorly drained, shaly, medium-textured soils that are underlain by soft, weathered shale bedrock.

Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVe. Soils that have a very severe risk of erosion if they are cultivated and not protected.

Capability unit IVe-58.—Steep, deep, well drained and moderately well drained, gravelly soils that have a moderately fine textured to moderately coarse textured subsoil.

Subclass IVs. Soils that have very severe limitations caused mainly by stoniness, shallowness to a restricting layer, and low available water capacity.

Capability unit IVs-34.—Gently sloping or strongly sloping, deep, somewhat poorly drained, stony soils that have a moderately coarse textured subsoil and a fragipan.

Subclass IVw. Soils that have very severe limitations caused mainly by excess water or an overflow hazard.

Capability unit IVw-36.—Nearly level, deep, poorly drained or very poorly drained soils that have a moderately coarse textured subsoil.

Capability unit IVw-80.—Nearly level, deep, poorly drained soils that have a moderately fine textured subsoil and are subject to frequent ponding or overflow.

Capability unit IVw-81.—Nearly level, deep, poorly drained soils that are subject to ponding or overflow and have a moderately fine textured subsoil and a coarse or moderately coarse textured substratum.

Capability unit IVw-82.—Nearly level or gently sloping, deep, poorly drained, gravelly soils that have a moderately fine textured subsoil.

Class V. Soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, woodland, or wildlife habitat. (None in Morris County.)

Class VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their farming use largely to pasture, woodland, or wildlife food and cover.

Subclass VIe. Soils that are severely limited, mainly by risk of erosion unless protective vegetative cover is established and maintained.

Capability unit VIe-65.—Steep, moderately deep or shallow, excessively drained or well-drained, medium-textured soils.

Subclass VIs. Soils that are severely limited by stoniness, shallowness to rock or other restricting layers, or low available water capacity.

Capability unit VIs-17.—Gently sloping or strongly sloping, shallow, well-drained, rocky or stony, medium-textured soils.

Capability unit VIs-19.—Gently sloping or strongly sloping, deep, well drained or moderately well drained, very stony soils that have a moderately coarse textured subsoil and a fragipan.

Capability unit VIs-34.—Steep, deep, somewhat poorly drained, very stony, moderately coarse textured soils that have a fragipan.

Capability unit VIs-58.—Steep, deep, excessively drained, very gravelly soils that have a moderately coarse textured subsoil.

Capaiblity unit VIs-61.—Steep, deep, well-drained, very stony soils that have a moderately fine textured subsoil.

Capability unit VIs-75.—Gently sloping and strongly sloping, deep, moderately well drained and somewhat poorly drained, very stony soils that have a moderately fine textured subsoil and a fragipan.

Subclass VIw. Soils that are severely limited, mainly by excessive wetness or hazard of overflow.

Capability unit VIw-46.—Nearly level, deep, very poorly drained soils that have a moderately fine textured to moderately coarse textured subsoil and are subject to very frequent flooding.

Capability unit VIw-86.—Nearly level, deep, poorly drained to moderately well drained, moderately coarse textured or medium-textured soils that are subject to frequent overflow.

Class VII. Soils have very severe limitations that make them unsuited to cultivation and restrict their use largely to grazing, woodland, or wildlife habitat.

Subclass VIIe. Soils that are severely limited by hazard of erosion.

Capability unit VIIe-66.—Very steep, shallow to soft fractured shale bedrock, excessively drained, shaly, medium-textured soils.

Subclass VIIs. Soils that are severely limited by coarse texture, shallowness to bedrock or other restricting layers, stoniness, or rock outcrops.

Capability unit VIIs-12.—Gently sloping to steep, deep, excessively drained, gravelly, coarse-textured soils.

Capability unit VIIs-22.—Gently sloping to very steep, shallow to deep, somewhat poorly drained to excessively drained, extremely stony or rocky soils that have a moderately coarse textured or medium-textured subsoil.

Capability unit VIIs-38.—Nearly level or gently sloping, deep, poorly drained, very stony or extremely stony soils that have a fragipan.

Capability unit VIIs-45.—Nearly level, deep, very poorly drained, very stony, moderately coarse textured soils that have a fragipan.

Capability unit VIIs-77.—Nearly level or gently sloping, deep, poorly drained, extremely stony, medium-textured or moderately fine textured soils that have a fragipan.

Subclass VIIw. Soils that are very severely limited by excess water or hazard of overflow.

Capability unit VIIw-41.—Nearly level, deep or shallow, very poorly drained, organic soils over moderately coarse textured to fine-textured mineral material.

Class VIII. Soils have severe limitations that preclude their use for commercial plant production and restrict their open-space uses to recreation, wildlife habitat, water supply, or esthetic purposes.

Subclass VIIIs. Soils that are very severely limited by coarse fragments, rock outcrops, and shallowness.

Capability unit VIIIs-23.—Very steep, extremely stony soils dominated by rock outcrops.

Estimated Yields

Table 3 shows estimates of yields for the principal crops grown in Morris County. The yields are shown for each of two levels of management.

In table 3, the yields in columns A are obtained under

TABLE 3.—*Estimated average yields per acre of principal crops under two levels of management*

[Ratings in columns A are for common management; those in columns B are the best current management. Absence of a rating indicates crop generally is not grown on this soil. The symbol > means more than]

Soil	Corn				Hay			
	Grain		Silage		Alfalfa-grass		Clover-grass	
	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Ton*	*Ton*	*Ton*	*Ton*	*Ton*	*Ton*
Adrian muck								
Alluvial land							2.5–2.8	3.0–3.2
Alluvial land, wet								
Annandale gravelly loam, 3 to 8 percent slopes	120–130	130–140	24–26	26–28	4.5–5.0	5.0–5.5	3.2–3.5	>3.5
Annandale gravelly loam, 8 to 15 percent slopes	110–120	120–130	22–24	24–26	4.0–4.5	5.0–5.5	3.0–3.2	3.2–3.5
Bartley loam, 0 to 3 percent slopes	120–130	130–140	24–26	26–28	4.5–5.0	5.0–5.5	3.2–3.5	>3.5
Bartley loam, 3 to 8 percent slopes	120–130	130–140	24–26	26–28	4.5–5.0	5.0–5.5	3.2–3.5	>3.5
Bartley gravelly loam, 8 to 15 percent slopes	110–120	120–130	22–24	24–26	4.0–4.5	5.0–5.5	3.0–3.2	3.2–3.5
Biddeford silt loam								
Boonton gravelly loam, 3 to 8 percent slopes	90–100	100–110	18–20	20–22	3.5–4.0	4.0–4.5	3.0–3.2	>3.5
Boonton gravelly loam, 8 to 15 percent slopes	80–90	90–100	16–18	18–20	3.0–3.5	3.5–4.0	2.8–3.0	3.2–3.5
Boonton and Haledon extremely stony soils, 8 to 15 percent slopes								
Califon loam, 0 to 3 percent slopes	90–100	110–120	16–18	18–20	3.0–3.5	3.5–4.0	2.8–3.0	3.2–3.5
Califon loam, 3 to 8 percent slopes	90–100	110–120	18–20	22–24	2.5–3.0	3.5–4.0	2.8–3.0	3.2–3.5
Califon loam, 8 to 15 percent slopes	80–90	100–110	16–18	20–22	2.0–2.5	3.0–3.5	2.5–2.8	3.0–3.2
Califon gravelly loam, 3 to 8 percent slopes	90–100	110–120	18–20	22–24	2.5–3.0	3.5–4.0	2.8–3.0	3.2–3.5
Califon very stony loam, 2 to 8 percent slopes								
Califon very stony loam, 8 to 15 percent slopes								
Califon loam, friable subsoil variant, 3 to 8 percent slopes	90–100	110–120	18–20	22–24	2.5–3.0	3.5–4.0	2.8–3.0	3.2–3.5
Carlisle muck								
Cokesbury gravelly loam, 0 to 3 percent slopes	80–90	100–110	16–18	20–22			2.2–2.5	2.8–3.0
Cokesbury gravelly loam, 3 to 8 percent slopes	80–90	100–110	16–18	20–22			2.2–2.5	2.8–3.0
Cokesbury extremely stony loam, 0 to 8 percent slopes								
Edneyville gravelly loam, 3 to 8 percent slopes	110–120	120–130	22–24	24–26	4.0–4.5	4.5–5.0	3.0–3.2	3.2–3.5
Edneyville gravelly loam, 8 to 15 percent slopes	100–110	110–120	24–22	22–24	3.5–4.0	4.0–4.5	2.8–3.0	3.0–3.2
Edneyville gravelly loam, 15 to 25 percent slopes	80–90	100–110	16–18	20–22	3.0–3.5	3.5–4.0	2.5–2.8	2.8–3.0
Ellington fine sandy loam, loamy subsoil variant, 3 to 8 percent slopes	100–110	110–120	20–22	22–24	4.0–4.5	4.5–5.0	3.0–3.2	3.2–3.5
Ellington fine sandy loam, loamy subsoil variant, 8 to 15 percent slopes	90–100	100–110	18–20	20–22	3.5–4.0	4.0–4.5	2.8–3.0	3.0–3.2
Ellington fine sandy loam, loamy subsoil variant, 15 to 25 percent slopes	80–90	90–100	16–18	18–20	3.0–3.5	3.5–4.0	2.5–2.8	2.8–3.0
Haledon silt loam, 3 to 8 percent slopes	80–90	90–100	16–18	18–20	3.0–3.5	3.5–4.0	2.5–2.8	2.8–3.0
Haledon, silt loam, 8 to 15 percent slopes	70–80	80–90	14–16	16–18	3.0–3.5	3.5–4.0	2.2–2.5	2.5–2.8
Hibernia stony loam, 3 to 15 percent slopes	60–70	70–80	12–14	14–16	2.5–3.0	3.0–3.5	2.0–2.2	2.2–2.5
Hibernia very stony loam, 15 to 25 percent slopes								
Holyoke rocky silt loam, 5 to 15 percent slopes								
Holyoke-Rock outcrop complex, 15 to 35 percent slopes								

TABLE 3.—*Estimated average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn				Hay			
	Grain		Silage		Alfalfa-grass		Clover-grass	
	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Ton*	*Ton*	*Ton*	*Ton*	*Ton*	*Ton*
Klinesville shaly silt loam, 25 to 35 percent slopes								
Made land, sanitary land fill								
Minoa silt loam, 0 to 3 percent slopes	90–100	110–120	18–20	22–24	2.5–3.0	3.5–4.0	2.8–3.0	3.0–3.2
Minoa silt loam, 3 to 8 percent slopes	90–100	110–120	18–20	22–24	3.0–3.5	3.5–4.0	2.8–3.0	3.0–3.2
Muck, shallow over clay								
Muck, shallow over loam								
Neshaminy gravelly silt loam, 3 to 8 percent slopes	120–130	130–140	24–26	26–28	4.5–5.0	5.0–5.5	3.2–3.5	>3.5
Neshaminy gravelly silt loam, 8 to 15 percent slopes	110–120	124–130	22–24	24–26	4.5–5.0	5.0–5.5	3.2–3.5	>3.5
Neshaminy very stony silt loam, 15 to 25 percent slopes								
Netcong gravelly sandy loam, 3 to 8 percent slopes	100–110	110–120	20–22	22–24	4.0–4.5	4.5–5.0	3.0–3.2	3.2–3.5
Netcong gravelly sandy loam, 8 to 15 percent slopes	90–100	100–110	18–20	20–22	4.0–4.5	4.5–5.0	3.0–3.2	3.2–3.5
Otisville gravelly loamy sand, 3 to 15 percent slopes								
Otisville gravelly loamy sand, 15 to 25 percent slopes								
Parker gravelly sandy loam, 3 to 15 percent slopes	60–70	70–80	12–14	14–16	2.0–2.5	2.5–3.0	1.8–2.0	2.0–2.2
Parker very gravelly sandy loam, 15 to 25 percent slopes								
Parker-Edneyville extremely stony sandy loams, 3 to 15 percent slopes								
Parker-Edneyville extremely stony sandy loams, 15 to 25 percent slopes								
Parker-Rock outcrop complex, 20 to 35 percent slopes								
Parsippany silt loam	50–60	80–90	12–14	16–18			1.5–1.8	2.5–2.8
Parsippany silt loam, sandy loam substratum	50–60	80–90	12–14	16–18			1.5–1.8	2.5–2.8
Pattenburg gravelly loam, 3 to 8 percent slopes	60–70	80–90	12–14	14–16	1.5–2.0	2.0–2.5	1.8–2.0	2.0–2.2
Pattenburg gravelly loam, 8 to 15 percent slopes	50–60	70–80	12–14	14–16	1.5–2.0	2.0–2.5	1.8–2.0	2.0–2.2
Penn shaly silt loam, 3 to 8 percent slopes	80–90	90–100	16–18	18–20	2.5–3.0	3.0–3.5	2.2–2.5	2.5–2.8
Penn shaly silt loam, 8 to 15 percent slopes	70–80	80–90	14–16	16–18	2.0–2.5	2.5–3.0	2.0–2.2	2.2–2.5
Penn-Klinesville shaly silt loams, 15 to 25 percent slopes								
Pits, sand and gravel								
Pompton sandy loam, 0 to 3 percent slopes	90–100	100–110	18–20	20–22	2.5–3.0	3.5–4.0	2.2–2.5	2.8–3.0
Pompton sandy loam, 3 to 8 percent slopes	80–90	100–110	16–18	22–24	2.5–3.0	3.5–4.0	2.5–2.8	3.0–3.2
Preakness sandy loam, 0 to 4 percent slopes	60–70	80–90	12–14	16–18			2.2–2.5	2.8–3.0
Preakness sandy loam, dark surface variant	60–70	80–90	12–14	16–18			2.0–2.2	2.5–2.8
Reaville shaly silt loam, deep variant, 0 to 5 percent slopes	60–70	80–90	12–14	16–18	2.0–2.5	3.0–3.5	2.2–2.5	2.5–2.8
Ridgebury very stony loam, 0 to 3 percent slopes								
Ridgebury extremely stony loam, 3 to 10 percent slopes								
Riverhead gravelly sandy loam, 0 to 3 percent slopes	90–100	100–110	18–20	20–22	2.5–3.0	3.5–4.0	2.2–2.5	2.8–3.0
Riverhead gravelly sandy loam, 3 to 8 percent slopes	90–100	100–110	18–20	20–22	2.5–3.0	3.5–4.0	2.2–2.5	2.8–3.0
Riverhead gravelly sandy loam, 8 to 15 percent slopes	70–80	90–100	16–18	18–20	2.5–3.0	3.5–4.0	2.0–2.2	2.5–2.8
Riverhead gravelly sandy loam, neutral variant, 2 to 8 percent slopes	90–100	100–110	18–20	20–22	3.0–3.5	3.0–3.5	2.2–2.5	2.8–3.0
Rockaway gravelly sandy loam, 3 to 8 percent slopes	90–100	100–110	18–20	20–22	4.0–4.5	4.5–5.0	3.0–3.2	3.2–3.5
Rockaway gravelly sandy loam, 8 to 15 percent slopes	70–80	90–100	16–18	18–20	3.5–4.0	4.0–4.5	3.0–3.2	3.2–3.5
Rockaway very stony sandy loam, 3 to 15 percent slopes								
Rockaway extremely stony sandy loam, 15 to 25 percent slopes								
Rockaway-Rock outcrop complex, 3 to 15 percent slopes								
Rockaway-Rock outcrop complex, 15 to 25 percent slopes								
Rockaway-Rock outcrop complex, 25 to 45 percent slopes								
Rock outcrop								
Rock outcrop-Rockaway complex, steep								
Turbotville loam, 0 to 3 percent slopes	90–100	110–120	18–20	22–24	2.5–3.0	3.5–4.0	2.8–3.0	3.2–3.5
Turbotville loam, 3 to 8 percent slopes	90–100	110–120	18–20	20–24	2.5–3.0	3.5–4.0	2.8–3.0	3.2–3.5
Urban land								
Urban land, wet								
Urban land-Edneyville complex								
Urban land-Haledon complex								
Urban land-Neshaminy complex								
Urban land-Penn complex								
Urban land-Preakness complex								
Urban land-Riverhead complex								
Urban land-Rockaway complex, gently sloping and sloping								
Urban land-Rockaway complex, moderately steep								
Urban land-Whippany complex								
Washington loam, 0 to 8 percent slopes	130–140	>140	26–28	>28	4.5–5.0	5.0–5.5	3.2–3.5	>3.5
Whippany silt loam, 0 to 3 percent slopes	80–90	100–110	16–18	20–22	3.0–3.5	4.0–4.5	2.8–3.0	3.0–3.2
Whippany silt loam, 3 to 8 percent slopes	80–90	100–110	16–18	20–22	2.5–3.0	4.0–4.5	2.8–3.0	3.0–3.2
Whippany silt loam, sandy loam substratum, 0 to 3 percent slopes	90–100	100–110	18–20	20–22	3.0–3.5	4.0–4.5	2.8–3.0	3.0–3.2
Whippany silt loam, sandy loam substratum, 3 to 8 percent slopes	80–90	100–110	16–18	20–22	2.5–3.0	4.0–4.5	2.8–3.0	3.0–3.2
Whitman very stony loam								

common management and those in columns B are obtained under intensive management. An intensive level of management includes practices that improve or maintain the tilth and available water capacity of the soil; the removal of excess water; practices that help to control erosion; suitable methods of plowing, preparing the seedbed, and cultivating; controlling weeds, diseases, and insects; maintaining fertility and reaction at optimum levels; selecting high-yield crop varieties suited to the area and soil; and planting, cultivating, and harvesting at the proper times and in the proper way.

In the common level of management the farmers use some, but not all, of the practices listed under intensive management, or the practices are used less effectively. This is the level of management common to most farms in the county.

Engineering Uses of the Soils[4]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning officials, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 4, 5, and 6, which show, respectively, several estimated soil properties significant in engineering, interpretations for various engineering uses, and results of engineering laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in table 5, and it also can be used to make other useful maps.

This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or require excavations to depths greater than those shown in the tables, generally depths of more than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning in soil science that may not be familiar to engineers. The Glossary defines many of these terms as they are commonly used in soil science.

Engineering classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*12*), used by the Soil Conservation Service, Department of Defense, and other agencies, and the AASHO system (*1*), adopted by the American Association of State Highway Officials.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML–CL.

The AASHO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system a soil is placed in one of seven basic groups that range from A–1 to A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b; A–2–4, A–2–5, A–2–6, A–2–7; and A–7–5 and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHO classification for tested soils, with group index numbers in parentheses, is shown in table 6; the estimated classification, without group index numbers, is shown in table 4 for all soils mapped in the county.

[4] CARMELO J. MONTANA, engineer, Soil Conservation Service, helped to prepare this section.

TABLE 4.—*Estimated chemical and*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. to other series that are listed in the first column of this

Soil series and map symbols	Depth to—		Depth from surface	Dominant USDA texture [1]	Classification
	Bedrock	Seasonal high water table			Unified
	Ft	*Ft*	*In*		
Adrian: Ad	>10	[2] 0	0–42	Muck	Pt
			42–60	Loamy sand	SM
Alluvial land:					
Ae	>6	[4] 1–4			
Most properties too variable to estimate.					
Am	>6	[4] 0			
Most properties too variable to estimate.					
Annandale: AnB, AnC	6–>10	>10	0–11	Gravelly loam	ML, CL, SM, SC
			11–32	Gravelly loam, gravelly clay loam	ML, CL, SM, SC
			32–44	Gravelly sandy loam	SM, SC, ML, CL
			44–76	Gravelly sandy loam	SM, SC, ML, CL
Bartley: BaA, BaB, BbC	6–>10	2–4	0–11	Loam	ML, CL
			11–32	Clay loam, loam, sandy clay loam	ML, CL
			32–42	Sandy loam	SM, SC, ML, CL
			42–88	Very fine sandy loam	SM, SC, ML, CL
Biddeford: Bd	>10	[4] 0	0–8	Muck	Pt
			8–18	Silt loam	CL
			18–44	Silty clay loam	CL, CH
			44–60	Silt loam	ML
*Boonton: BoB, BoC, BpC	>6	1½–>6	0–6	Gravelly loam	ML
For Haledon part of BpC, see Haledon series.			6–30	Fine sandy loam	ML, CL, SM
			30–45	Gravelly fine sandy loam	ML, SM
			45–60	Gravelly sandy loam	SM
Califon: CaA, CaB, CaC, CbB, CcB, CcC.	>6	½–4	0–9	Loam	ML, CL
			9–23	Clay loam	CL, SC, ML
			23–57	Sandy loam	SM, SC
			57–60	Sandy loam	SM, SC
Califon variant: CdB	>10	½–4	0–12	Gravelly loam	ML, CL
			12–40	Sandy loam, sandy clay loam, gravelly sandy clay loam.	ML, CL, SM, SC
			40–60	Sandy loam	SM, SC
Carlisle: Cm	>10	[2] 0	0–60	Muck	Pt
Cokesbury: CoA, CoB, CsB	>6	0–1	0–9	Gravelly loam, extremely stony loam.	ML, SM
			9–25	Gravelly clay loam, loam	ML, CL, SM, SC
			25–35	Loam	ML, CL
			35–60	Gravelly loam	ML, CL, SM, SC
Edneyville: EdB, EdC, EdD	6–>10	>10	0–10	Gravelly loam	SM, ML, CL
			10–37	Sandy loam, sandy clay loam	SC, SM, ML, CL
			37–60	Sandy loam	SM
Ellington variant: ElB, ElC, ElD	>10	½–4	0–10	Fine sandy loam	SM, SC, ML, CL
			10–20	Fine sandy loam	SC, SM, ML, CL
			20–40	Fine sandy loam	SC, SM, ML, CL
			40–60	Gravelly clay loam	ML, CL, SM, SC
Haledon: HaB, HaC	>5	½–1½	0–10	Silt loam	ML, CL
			10–18	Silt loam	ML, CL
			18–46	Silt loam	ML, CL
			46–64	Very fine sandy loam	SM, SC
Hibernia: HbC, HlD	>10	½–1½	0–7	Gravelly loam	SM
			7–20	Gravelly sandy loam	SM
			20–46	Gravelly sandy loam	SM
			46–60	Stony sandy loam	SM
Holyoke: HoC, HrE	1–1½	([5])	0–6	Gravelly silt loam	SM, ML
Rock outcrop part of HrE too variable to estimate.			6–17	Cobbly silt loam	ML
			17	Basalt bedrock.	

physical properties of the soils

These soils may differ in properties and limitations. For this reason it is necessary to follow carefully the instructions for referring table. The symbol < means less than; > means more than]

Classification—Continued	Coarse fraction greater than 3 inches	Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO		No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				
						In per hr	*In per in of depth*	*pH*	
	0					>6.0	0.30–0.35	5.6–6.5	[3] Low.
A–2	0–2	90–100	85–100	50–75	15–30	>6.0	0.08–0.12	5.6–6.5	Low.
A–4	0–5	85–95	80–95	60–85	40–60	0.6–2.0	0.16–0.20	5.1–6.0	Low.
A–6	0–3	85–95	75–85	55–80	40–70	0.6–2.0	0.16–0.20	5.1–6.0	Low.
A–4, A–6	0–3	85–95	75–85	70–85	40–60	<0.2	0.10–0.14	5.1–6.0	Low.
A–4, A–6	0–3	85–95	70–80	50–65	40–60	0.6–2.0	0.10–0.14	5.1–6.0	Low.
A–4, A–7	0–5	95–100	75–95	75–85	60–75	0.6–2.0	0.16–0.20	6.1–6.5	Low.
A–4, A–6	0–5	95–100	75–95	70–85	55–75	0.6–2.0	0.12–0.18	5.6–6.5	Moderate.
A–2, A–4	0–5	90–100	75–95	65–80	30–55	<0.2	0.08–0.12	6.6–7.3	Low.
A–2, A–4	0–5	95–100	75–95	70–85	30–55	0.6–2.0	0.16–0.20	6.6–7.3	Low.
A–8	0					2.0–6.0	0.28–0.35	5.6–6.5	[3] Low.
A–4	0	100	95–100	70–85	65–80	0.2–0.6	0.22–0.26	5.6–6.5	Low.
A–6, A–7	0	100	95–100	85–95	70–85	<0.2	0.14–0.18	5.6–6.5	Moderate.
A–6	0	100	95–100	80–95	65–80	0.2–0.6	0.14–0.18	6.1–7.3	Low.
A–4	0–15	85–100	80–95	65–80	55–70	0.6–2.0	0.15–0.19	4.5–5.5	Low.
A–4	0–15	85–100	80–95	75–85	55–75	0.6–2.0	0.15–0.19	4.5–5.5	Low.
A–4	0–15	85–100	80–95	70–85	40–65	>0.2	0.06–0.10	5.6–7.3	Low.
A–2	0–15	80–95	75–85	65–80	25–35	0.2–0.6	0.06–0.10	5.6–7.3	Low.
A–4	0–10	80–95	75–95	70–90	55–70	0.6–2.0	0.18–0.24	5.1–6.0	Low.
A–4, A–6	0–10	90–95	85–95	45–60	40–75	0.6–2.0	0.16–0.22	5.1–6.0	Moderate.
A–2, A–4	0–5	90–95	85–95	50–65	30–50	>0.2	0.06–0.10	5.1–6.0	Low.
A–2, A–4	0–5	90–95	85–90	55–70	30–40	0.6–2.0	0.16–0.20	5.1–6.0	Low.
A–4	0–5	85–100	80–100	55–75	55–70	0.6–2.0	0.16–0.20	5.1–6.5	Low.
A–4	0–5	80–95	70–90	60–75	40–65	0.6–2.0	0.14–0.18	4.5–6.0	Low.
A–2, A–4	0–5	95–100	85–95	50–75	30–40	0.6–2.0	0.12–0.16	4.5–6.0	Low.
	0					>6.0	0.30–0.35	5.6–6.5	[3] Low.
A–4	0–15	80–95	75–85	65–85	45–70	0.6–2.0	0.14–0.16	5.6–6.0	Low.
A–4, A–6	0–5	80–95	75–85	60–70	45–70	0.2–0.6	0.12–0.16	5.1–6.0	Moderate.
A–4	0–5	80–95	70–85	55–70	55–70	<0.2	0.08–0.12	5.1–6.0	Low.
A–4	0–5	80–95	50–70	45–65	45–65	<0.2	0.10–0.14	5.1–6.0	Low.
A–2, A–4	0–15	70–85	65–85	45–60	40–60	0.6–2.0	0.12–0.16	4.5–5.5	Low.
A–2, A–4	0–10	80–90	70–85	55–75	30–55	0.6–2.0	0.12–0.16	4.5–5.5	Low.
A–2, A–4	0–10	85–100	80–90	60–85	25–40	0.6–2.0	0.12–0.16	4.5–5.5	Low.
A–4	0–3	95–100	90–95	70–90	40–55	0.6–2.0	0.14–0.18	4.5–5.5	Low.
A–4	0–3	95–100	90–100	70–90	40–55	0.6–2.0	0.13–0.18	4.5–5.5	Low.
A–4	0–3	85–95	75–90	60–90	40–55	0.2–0.6	0.12–0.16	4.5–5.5	Low.
A–2, A–4	0–5	75–85	65–85	55–75	25–65	0.2–0.6	0.10–0.16	4.5–5.5	Low.
A–4	0–15	90–100	85–100	65–85	55–80	0.6–2.0	0.16–0.20	5.1–5.5	Low.
A–4	0–15	85–100	75–100	65–85	55–85	0.6–2.0	0.16–0.20	5.1–5.5	Low.
A–4	0–10	85–100	75–95	65–85	55–85	<0.2	0.06–0.10	5.1–5.5	Low.
A–2, A–4	0–10	75–100	70–95	55–70	30–50	0.2–0.6	0.06–0.10	6.1–7.3	Low.
A–2, A–4	0–5	70–85	65–75	55–70	30–45	0.6–2.0	0.08–0.12	4.5–5.5	Low.
A–2, A–4	0–5	70–90	65–80	60–75	25–45	0.6–2.0	0.08–0.12	4.5–5.5	Low.
A–2, A–4	0–10	70–90	65–80	55–70	25–40	<0.2	0.08–0.12	4.5–5.5	Low.
A–2	0–10	80–95	60–75	55–70	25–35	0.2–0.6	0.05–0.10	4.5–5.5	Low.
A–4	0–10	75–95	75–85	50–65	45–60	0.6–2.0	0.15–0.20	4.5–5.5	Low.
A–4	0–10	70–95	70–85	55–70	55–65	0.6–2.0	0.15–0.20	4.5–5.5	Low.

TABLE 4.—*Estimated chemical and*

Soil series and map symbols	Depth to—		Depth from surface	Dominant USDA texture [1]	Classification
	Bedrock	Seasonal high water table			Unified
	Ft	*Ft*	*In*		
Klinesville: KlE	1–1½	([5])	0–2	Shaly silt loam	GM, SM, SC
			2–14	Very shaly silt loam	GM, SM, SC
			14	Shale bedrock.	
Made land: Ma. Too variable to estimate.					
Minoa: MlA, MlB	>10	½–1½	0–6	Silt loam	ML, CL
			6–30	Silt loam, fine sandy loam	ML, CL, SM, SC
			30–60	Loamy fine sand, silt loam, and loamy very fine sand.	SM, ML
Muck:					
Ms	>10	[2] 0	0–30	Muck	Pt
			30–60	Clay	CL, CH
Mu	>10	[2] 0	0–25	Muck	Pt
			25–60	Loam	ML, CL
Neshaminy: NeB, NeC, NfD	4–10	>10	0–8	Gravelly silt loam	ML, CL
			8–39	Gravelly and cobbly clay loam	ML, CL, SC, GM, GC
			39–54	Cobbly clay loam	ML, CL, GM, GC
			54–60	Sandy loam	GM, SM
Netcong: NtB, NtC	>10	>10	0–13	Gravelly sandy loam	SM, SC
			13–41	Gravelly sandy loam, sandy loam	SM, SC
			41–60	Sandy loam	SM, SC
Otisville: OtC, OtD	>10	>10	0–8	Gravelly loamy sand	GM, SM, SP–SM
			8–14	Gravelly loamy sand	SM, SP–SM, GP–GM
			14–60	Very gravelly sand	GM, GP–GM, SM, SP–SM
*Parker: PaC, PbD, PeC, PeD, PfE. For Edneyville part of PeC and PeD, see Edneyville series. Rock outcrop part of PfE too variable to estimate.	4–10	>10	0–5	Very gravelly sandy loam	GM, SM
			5–31	Very gravelly loam, very gravelly sandy loam.	GM, GC
			31–60	Sandy loam	GM
Parsippany:					
Ph	>10	[2] 0–1	0–7	Silt loam	ML, CL
			7–34	Clay loam, silty clay loam, silt loam	ML, CL
			34–64	Silty clay loam	ML, CL
Pk	>10	0–1	0–7	Silt loam	ML, CL
			7–34	Clay loam, silty clay loam, silt loam	ML, CL
			34–60	Fine sandy loam, silt loam	SM, SC, ML, CL
Pattenburg: PlB, PlC	3½–10	>10	0–10	Gravelly loam	SM
			10–34	Gravelly loam	SM
			34–60	Very gravelly sandy loam	GM, SM
*Penn: PnB, PnC, PoD. For Klinesville part of PoD, see Klinesville series.	1½–3½	4–>6	0–8	Shaly silt loam	ML, CL
			8–30	Shaly silt loam	ML, CL
			30–36	Very shaly silt loam	GM, SM
			36	Shale or siltstone bedrock.	
Pits: Ps.[6] Too variable to estimate.					
Pompton: PtA, PtB	>10	[2] ½–1½	0–7	Sandy loam	SM
			7–36	Sandy loam, gravelly sandy loam	SM
			36–60	Gravelly loamy sand	SM, SP–SM
Preakness: PvA	>6	[4] 0–1	0–8	Sandy loam	SM, SC
			8–30	Sandy loam	SM, SC
			30–60	Loamy sand, sandy loam	SM, SP–SM
Preakness variant: Pw	>10	[2] 0	0–8	Muck	Pt
			8–32	Loamy sand, sandy loam	SM
			32–60	Loamy sand, sandy loam	SM, SP–SM

physical properties of the soils—Continued

Classification—Continued	Coarse fraction greater than 3 inches	Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO		No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				
						In per hr	*In per in of depth*	*pH*	
A–2, A–4	0–10	50–85	50–80	30–60	20–40	2.0–6.0	0.12–0.15	5.1–5.5	Low.
A–2, A–4	0–10	35–60	35–50	20–40	15–40	2.0–6.0	0.07–0.11	5.1–6.0	Low.
A–4	0–5	90–100	85–100	60–80	60–80	0.6–2.0	0.20–0.24	5.6–7.0	Low.
A–4	0–5	95–100	85–100	80–95	45–85	0.2–2.0	0.16–0.20	5.1–6.5	Low.
A–2, A–4	0–5	95–100	85–100	75–90	15–70	0.6–6.0	0.10–0.14	6.1–7.3	Low.
A–8	0					>6.0	0.30–0.35	5.6–6.5	[3] Low.
A–6, A–7	0	100	95–100	85–95	75–90	0.2–0.6	0.14–0.18	6.1–7.3	Moderate.
A–8	0					>6.0	0.30–0.35	5.6–6.5	[3] Low.
A–4, A–6	0–5	90–100	85–95	75–90	55–70	0.2–2.0	0.18–0.22	5.6–7.3	Low.
A–4	0–10	85–100	65–90	60–70	60–70	0.6–2.0	0.18–0.23	5.6–6.0	Low.
A–4, A–6	5–25	75–90	60–90	50–80	45–75	0.6–2.0	0.16–0.20	5.6–6.0	Moderate.
A–4	10–30	70–80	65–80	55–75	45–70	0.6–2.0	0.16–0.20	5.6–6.0	Low.
A–2, A–4	0–30	50–90	50–90	40–55	25–40	0.6–2.0	0.14–0.18	5.6–6.0	Low.
A–2, A–4	0–10	75–95	70–80	50–65	25–40	2.0–6.0	0.10–0.14	4.5–6.5	Low.
A–2, A–4	0–10	75–90	60–90	50–65	25–40	2.0–6.0	0.09–0.13	4.5–6.5	Low.
A–2, A–4	0–10	75–90	65–80	50–65	30–40	2.0–6.0	0.09–0.13	4.5–6.5	Low.
A–1, A–2	5–15	55–70	50–70	30–45	10–20	>6.0	0.06–0.10	4.5–6.0	Low.
A–1, A–2	5–15	55–80	50–80	20–35	10–25	>6.0	0.05–0.09	4.5–6.0	Low.
A–1	5–35	45–60	35–60	15–30	5–15	>6.0	0.02–0.05	4.5–6.0	Low.
A–1, A–2	15–30	55–70	40–70	15–30	15–30	2.0–6.0	0.10–0.14	4.5–5.5	Low.
A–1, A–2, A–4	15–30	50–65	40–65	20–35	15–40	2.0–6.0	0.08–0.12	4.5–5.5	Low.
A–1, A–2	20–35	50–65	30–45	15–30	20–30	>6.0	0.08–0.12	4.5–5.5	Low.
A–4, A–6, A–7	0	100	95–100	70–85	60–85	0.2–0.6	0.20–0.26	5.6–6.0	Low.
A–7, A–6	0	100	95–100	85–95	65–90	<0.2	0.18–0.24	5.1–6.5	Moderate.
A–6	0	100	95–100	80–95	75–90	0.2–0.6	0.14–0.18	6.1–7.3	Moderate.
A–4, A–6, A–7	0	100	95–100	70–85	60–85	0.2–0.6	0.18–0.22	5.6–6.0	Low.
A–7, A–6	0	100	95–100	85–95	65–90	<0.2	0.18–0.22	5.1–6.5	Moderate.
A–4	0	100	95–100	70–90	40–70	0.6–2.0	0.14–0.20	6.1–7.3	Low.
A–4	0–10	70–85	65–85	50–65	40–50	0.6–2.0	0.16–0.20	5.1–5.5	Low.
A–4	0–10	75–90	60–85	60–75	40–50	0.6–2.0	0.14–0.18	5.1–5.5	Low.
A–2	10–25	60–75	45–65	45–60	25–35	>6.0	0.06–0.10	4.5–5.0	Low.
A–4, A–6	0–5	80–95	70–85	60–75	60–70	0.2–2.0	0.17–0,22	4.5–5.5	Low.
A–4, A–6	0–10	80–95	65–80	60–75	55–70	0.6–2.0	0.13–0.18	4.5–6.5	Low.
A–2, A–4	0–20	55–70	40–60	35–50	25–40	2.0–>6.0	0.09–0.12	5.1–6.5	Low.
A–2, A–4	0–5	85–100	85–100	70–85	30–40	2.0–6.0	0.12–0.16	4.5–5.5	Low.
A–2, A–4	0–5	85–100	80–100	70–85	25–40	2.0–6.0	0.14–0.18	5.1–5.5	Low.
A–2	0–5	70–100	60–100	60–90	10–25	>6.0	0.06–0.10	4.5–5.5	Low.
A–2, A–4	0–5	95–100	90–100	60–75	30–40	2.0–6.0	0.12–0.16	4.5–5.5	Low.
A–2, A–4	0–5	85–100	80–95	35–50	30–40	2.0–6.0	0.10–0.16	4.5–5.5	Low.
A–1, A–2	0–10	75–100	50–100	35–50	10–35	2.0–>6.0	0.07–0.13	4.5–5.5	Low.
A–8						>6.0	0.30–0.35	4.5–6.0	Low.
A–2	0–5	85–100	65–80	35–50	20–35	2.0–6.0	0.08–0.12	5.1–6.0	Low.
A–2	0–15	90–100	80–100	35–50	10–30	2.0–6.0	0.05–0.10	4.0–6.0	Low.

TABLE 4.—*Estimated chemical and*

Soil series and map symbols	Depth to—		Depth from surface	Dominant USDA texture [1]	Classification
	Bedrock	Seasonal high water table			Unified
	Ft	*Ft*	*In*		
Reaville variant: ReB	3½–5	½–4	0–8	Shaly silt loam	ML, CL
			8–30	Shaly silt loam	ML, CL
			30–45	Very shaly silt loam	GM, GC, ML, CL
			45	Shale bedrock.	
Ridgebury: RgA, RlB	>10	0–1	0–9	Gravelly loam, sandy loam	GM, GC, SM, SC
			9–14	Gravelly sandy loam	SM, SC
			14–36	Gravelly sandy loam	SM
			36–60	Gravelly sandy loam	SM
Riverhead: RmA. RmB, RmC	>10	>10	0–4	Gravelly sandy loam	SM, SC
			4–28	Gravelly sandy loam	SM, SC
			28–60	Loamy sand, gravelly loamy sand	SM
Riverhead variant: RnB	>10	6–>10	0–10	Gravelly sandy loam	SM
			10–38	Gravelly sandy loam, gravelly loamy sand.	SM
			38–66	Gravelly loamy sand	SM, SP–SM
*Rockaway: RoB, RoC, RpC, RrD, RsC, RsD, RsE. Rock outcrop part of RsC, RsD, and RsE too variable to estimate.	>10	1½–>10	0–8	Cobbly sandy loam	SM, SC
			8–20	Gravelly sandy loam	SM, SC
			20–40	Gravelly sandy loam	SM, SC
			40–60	Gravelly sandy loam	SM, SC
*Rock outcrop: Rt, RvF. Properties too variable to estimate. For Rockaway part of RvF, see Rockaway series.					
Turbotville: TuA, TuB	5–>8	½–1½	0–8	Loam	ML, CL
			8–20	Loam	ML, CL
			20–36	Loam	ML, CL
			36–60	Loam, gravelly fine sandy loam	ML, SM, SC
*Urban land: Ua, Ub, Ue, Uh, Uk, Um, Un, Up, UrC, UrD, Uw. Properties too variable to estimate. For Edneyville part of Ue, Haledon part of Uh, Neshaminy part of Uk, Penn part of Um, Preakness part of Un, Riverhead part of Up, Rockaway part of UrC and UrD, and Whippany part of Uw, see the respective series.					
Washington: WaB	>6	>10	0–7	Loam	ML, CL
			7–20	Loam	ML, CL
			20–41	Clay loam, silt loam	ML, CL
			41–78	Silt loam	ML, CL
Whippany:					
WhA, WhB	>10	½–1½	0–9	Silt loam	ML, CL
			9–40	Silt loam, silty clay loam	CL, CH
			40–60	Silt loam	ML, CL
WlA, WlB	>10	½–1½	0–9	Silt loam	ML, CL
			9–40	Silt loam, silty clay loam	CL, CH
			40–60	Sandy loam	SM
Whitman: Wm	>10	0	0–8	Cobbly loam	ML, CL, SM, SC
			8–20	Gravelly sandy loam	ML, SM, SC, CL
			20–40	Gravelly sandy loam	SM
			40–60	Gravelly loamy sand, sandy loam	SM

[1] Textures listed for each horizon are those of the representative profile. The full range of textures in the horizons common in this county is listed for each series following the representative profile description.
[2] Flooding in places.
[3] High subsidence upon drying, low swell.

physical properties of the soils—Continued

Classification—Continued	Coarse fraction greater than 3 inches	Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO		No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				
						In per hr	*In per in of depth*	*pH*	
A–4, A–6	0–5	85–100	80–90	65–80	60–80	0.6–2.0	0.18–0.22	4.5–6.5	Low.
A–4, A–6	0–5	80–95	55–95	55–80	55–80	0.2–0.6	0.16–0.20	4.5–6.0	Low.
A–2, A–4	0–10	55–70	35–60	30–60	30–60	2.0–6.0	0.10–0.16	4.5–6.5	Low.
A–2, A–4	0–15	65–80	65–80	50–65	30–50	0.6–2.0	0.14–0.18	4.5–6.0	Low.
A–2, A–4	0–10	80–95	65–80	60–75	30–45	0.6–2.0	0.10–0.14	4.5–6.0	Low.
A–2, A–4	0–10	85–95	65–80	55–70	25–40	<0.2	0.08–0.12	4.5–6.0	Low.
A–2, A–4	0–5	85–100	65–80	60–75	25–40	0.6–2.0	0.06–0.10	4.5–5.5	Low.
A–2	0–10	75–100	70–95	50–60	20–30	2.0–6.0	0.10–0.14	4.5–5.5	Low.
A–2	0–5	80–100	70–95	60–75	25–35	2.0–6.0	0.10–0.14	4.5–5.5	Low.
A–1, A–2	0–5	70–100	45–95	35–80	15–30	>6.0	0.06–0.10	4.5–5.5	Low.
A–2	0	80–95	65–90	45–60	25–35	2.0–6.0	0.10–0.14	5.1–5.5	Low.
A–2	0	80–95	65–90	50–70	15–35	2.0–6.0	0.10–0.14	5.6–6.5	Low.
A–1, A–2	0	75–90	50–90	45–75	10–25	2.0–>6.0	0.06–0.10	6.6–7.3	Low.
A–2, A–4	0–20	70–85	60–75	55–70	25–40	0.6–2.0	0.10–0.14	4.5–5.5	Low.
A–2, A–4	0–15	75–90	65–85	60–75	25–40	0.6–2.0	0.10–0.14	4.5–5.5	Low.
A–2, A–4	0–15	75–90	65–80	55–70	25–45	<0.2	0.06–0.10	4.5–5.5	Low.
A–2, A–4	0–15	80–95	65–80	55–70	25–45	0.2–2.0	0.10–0.14	4.5–5.5	Low.
A–4	0–5	95–100	85–95	75–85	65–75	0.6–2.0	0.20–0.24	5.6–6.5	Low.
A–4, A–6	0–5	95–100	85–95	80–90	65–75	0.2–2.0	0.18–0.22	5.6–6.5	Moderate.
A–4, A–6	0–10	90–100	85–95	80–85	60–75	<0.2	0.08–0.12	5.6–6.5	Moderate.
A–4	0–5	95–100	80–90	75–90	40–55	0.6–2.0	0.16–0.20	5.6–6.5	Low.
A–4	0–2	95–100	80–95	75–85	65–75	2.0–6.0	0.20–0.24	5.6–6.0	Low.
A–4, A–6	0–2	95–100	85–95	80–90	65–75	0.6–2.0	0.18–0.22	5.6–6.0	Low.
A–4, A–6	0–2	95–100	90–95	75–95	60–75	0.6–2.0	0.18–0.22	6.1–7.3	Moderate.
A–4, A–6	0	100	95–100	80–95	60–75	0.6–6.0	0.16–0.20	6.6–7.3	Low.
A–4, A–6	0	100	85–100	75–100	65–75	0.6–2.0	0.20–0.26	5.6–6.0	Low.
A–6, A–7	0–1	100	95–100	95–100	65–90	<0.2	0.18–0.24	5.6–6.0	Moderate.
A–4, A–6	0–1	100	90–100	90–100	75–90	<0.2	0.16–0.20	6.1–7.3	Moderate or low.
A–4, A–6	0	100	85–100	75–100	65–75	0.6–2.0	0.20–0.26	5.6–6.0	Low.
A–6, A–7	0–1	100	95–100	95–100	65–90	<0.2	0.18–0.24	5.6–6.0	Moderate.
A–2, A–4	0	100	90–100	90–100	30–45	0.6–6.0	0.14–0.18	6.1–7.3	Low.
A–4	0–10	85–95	80–95	70–85	45–60	2.0–6.0	0.16–0.20	4.5–6.0	Low.
A–4	5–10	85–95	80–95	70–80	45–60	0.6–2.0	0.12–0.16	4.5–6.0	Low.
A–4	5–10	85–95	75–90	65–80	35–50	<0.2	0.06–0.10	4.5–6.0	Low.
A–2	0–10	85–95	75–90	65–80	15–30	0.2–2.0	0.05–0.12	4.5–6.0	Low.

[4] Frequent flooding.
[5] Not determined.
[6] Fractured shale and sandstone is at depth of 36 inches.

TABLE 5.—*Interpretations of the soils*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. to other series that are listed in

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil	Sand and gravel	Road fill	Pond reservoir areas	Dikes and other embankments
Adrian: Ad	Poor: seasonal high water table at surface; highly organic material.	Unsuitable: no sand or gravel.	Unsuitable: unstable organic material.	Seasonal high water table at surface.	Unsuitable: highly organic material.
Alluvial land: Ae	Good: seasonal high water table at a depth of 1 foot to 4 feet.	Unsuitable above a depth of 40 inches; variable below a depth of 40 inches.	Fair: high frost-action potential; excessive cobbles and stones below a depth of 40 inches in places.	Seasonal high water table at a depth of 1 foot to 4 feet.	Good to poor stability.
Am	Poor: seasonal high water table at surface.	Unsuitable above a depth of 30 inches; variable below a depth of 30 inches.	Poor: seasonal high water table at surface; high frost-action potential.	Seasonal high water table at surface.	Good to poor stability; excessive cobbles and stones in places.
Annandale: AnB, AnC	Poor: excessive gravel.	Poor: excessive fines.	Fair: moderate frost action potential; common stones in places.	Slow permeability in fragipan.	Low permeability when compacted; good stability; common stones.
Bartley: BaA, BaB, BbC	Fair for BaA, BaB: gravelly. Poor for BbC: excessive gravel.	Unsuitable: excessive fines.	Fair: high frost-action potential.	Seasonal high water table at a depth of 2 to 4 feet; slow permeability in fragipan.	Good stability; low permeability when compacted.
Biddeford: Bd	Poor: seasonal high water table at surface.	Unsuitable: no sand or gravel.	Poor: high water table hinders excavation.	Seasonal high water table at surface; slow permeability in fragipan; generally suitable for dug ponds.	Fair to poor stability; low permeability when compacted.
*Boonton: BoB, BoC, BpC. For Haledon part of BpC, see Haledon series.	Poor: excessive coarse fragments; BpC extremely stony.	Poor: excessive fines; limited sand and gravel.	Fair for BoB, BoC, A–4 material; high frost-action potential. Poor for BpC: excessive stones.	Slow permeability in fragipan; excessive stones in BpC.	Fair to poor stability; fair to good compaction characteristics.
Califon: CaA, CaB, CaC, CbB, CcB, CcC.	Fair for CaA, CaB, CaC: low content of gravel. Poor for CbB, CcB, CcC: excessive gravel and stones.	Unsuitable: excessive fines.	Fair for CaA, CaB, CaC, CbB: A–4 and A–6 material; seasonal high water table perched at a depth of ½ foot to 4 feet; high frost action potential. Poor for CcB, CcC: excessive stones.	Seasonal high water table perched at a depth of ½ foot to 4 feet; slow permeability in fragipan.	Good stability; low permeability when compacted; excessive stones in CcB and CcC.
Califon variant: CdB	Fair: moderate amount of gravel.	Unsuitable: excessive fines.	Fair: seasonal high water table at a depth of ½ foot to 4 feet; high frost-action potential.	Seasonal high water table at a depth of ½ foot to 4 feet; hazard of seepage in summer.	Good stability; low permeability when compacted.

for engineering purposes

These soils may differ in properties and limitations. For this reason it is necessary to follow carefully the instructions for referring the first column of this table]

Soil features affecting—Continued					
Drainage for crops and pasture	Irrigation	Terraces and diversions	Grass waterways	Winter grading	Shallow excavations
Seasonal high water table at surface; rapid permeability; inadequate outlets.	High intake rate; rapid permeability; high available water capacity.	Not applicable	Not applicable	Seasonal high water table at surface.	Seasonal high water table at surface; low bearing capacity in organic material.
Seasonal high water table at a depth of 1 foot to 4 feet; subject to frequent flooding.	Seasonal high water table at a depth of 1 foot to 4 feet; high available water capacity; subject to frequent flooding.	Not applicable	Not applicable	Seasonal high water table at a depth of 1 foot to 4 feet.	Seasonal high water table at a depth of 1 foot to 4 feet; subject to frequent flooding.
Subject to frequent flooding; seasonal high water table at surface.	Subject to frequent flooding; seasonal high water table at surface.	Not applicable	Not applicable	Seasonal high water table at a depth of 1 foot to 4 feet.	Seasonal high water table at a depth of 1 foot to 4 feet; subject to frequent flooding.
Lateral seepage over fragipan in places.	Moderate intake rate; moderate available water capacity; hazard of erosion moderate where slopes are 8 to 15 percent.	All features favorable	All features favorable.	Perched water table in places in winter and spring; lateral seepage above fragipan.	All features favorable.
Lateral seepage above fragipan.	Moderate intake rate; moderate available water capacity; hazard of erosion where slopes are 8 to 15 percent.	Fragipan at a depth of 2 to 3 feet.	Fragipan at a depth of 2 to 3 feet.	Seasonal high water table at a depth of 2 to 4 feet.	Seasonal high water table at a depth of 2 to 4 feet.
Seasonal high water table at surface; slow permeability in fragipan; subject to frequent flooding.	Moderate intake rate; high available water capacity; seasonal high water table at surface; needs drainage before irrigation.	Not applicable	Not applicable	Seasonal high water table at surface.	Seasonal high water table at surface.
Slow permeability; seasonal water table perched at a depth of 1½ to 6 feet; excessive stones in BpC.	Moderate intake rate; slow permeability in fragipan; moderate available water capacity; excessive stones in BpC.	Seasonal high water table perched at a depth of 1½ to 6 feet; excessive stones in BpC.	Seasonal high water table perched at a depth of 1½ to 6 feet; excessive stones in BpC.	Seasonal high water table perched at a depth of 1½ to 6 feet; excessive stones in BpC.	Seasonal high water table perched at a depth of 1½ to 6 feet; lateral seepage above fragipan; bedrock generally at a depth below 6 feet.
Seasonal high water table at a depth of ½ foot to 4 feet; slow permeability in fragipan at a depth of 20 to 30 inches; excessive stones in CcB and CcC.	Moderate intake rate; moderate available water capacity; slow permeability in fragipan at a depth of 20 to 30 inches; excessive stones in CcB and CcC.	Seasonal high water table perched at a depth of ½ foot to 4 feet; lateral seepage above fragipan to a depth of 20 to 30 inches; excessive stones in CcB and CcC.	Seasonal high water table perched at a depth of ½ foot to 4 feet; lateral seepage above fragipan to a depth of 20 to 30 inches.	Seasonal high water table at a depth of ½ foot to 4 feet; lateral seepage above fragipan.	Hard bedrock generally below a depth of 6 feet; seasonal high water table at a depth of ½ foot to 4 feet; lateral seepage above fragipan.
Seasonal high water table at a depth of ½ foot to 4 feet; moderate permeability.	Moderate intake rate; moderate available water capacity; moderate permeability.	Seasonal high water table at a depth of ½ foot to 4 feet.	Seasonal high water table at a depth of ½ foot to 4 feet.	Seasonal high water table at a depth of ½ foot to 4 feet.	Seasonal high water table at a depth of ½ foot to 4 feet; ditchbanks readily collapse.

TABLE 5.—*Interpretations of the soils*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil	Sand and gravel	Road fill	Pond reservoir areas	Dikes and other embankments
Carlisle: Cm	Poor: seasonal high water table at surface; highly organic material.	Unsuitable: no sand or gravel.	Unsuitable: unstable, highly organic material.	Seasonal high water table; suitable for dug ponds.	Poor stability; poor compaction characteristics; high permeability; low bearing capacity.
Cokesbury: CoA, CoB, CsB	Poor: seasonal high water table; excessive gravel and stones.	Unsuitable: excessive fines; seasonal high water table at a depth of 0 to 1 foot; excessive stones in CsB.	Poor: A–4 and A–6 material; seasonal high water table at a depth of 0 to 1 foot; high frost-action potential; excessive stones in CsB.	Seasonal high water table at a depth of 0 to 1 foot.	Good stability; low permeability when compacted; excessive stones in CsB.
Edneyville: EdB, EdC, EdD	Poor: excessive gravel and stones.	Poor: excessive fines.	Good for EdB, EdC: moderate to high frost-action potential. Poor for EdD: hazard of erosion.	Hazard of seepage in pervious substratum in places.	Good stability; low permeability when compacted.
Ellington variant: EIB, EIC, EID.	Good for EIB, EIC: seasonal high water table at a depth of ½ foot to 4 feet. Poor for EID: severe hazard of erosion at site of removal.	Poor: excessive fines.	Fair for EIB, EIC: A–4 material; seasonal high water table at a depth of ½ foot to 4 feet; high frost-action potential. Poor for EID: severe hazard of erosion at site of removal.	Hazard of seepage in places; slope limitation in EID; seasonal high water table at a depth of ½ foot to 4 feet.	Fair stability; fair compaction characteristics.
Haledon: HaB, HaC	Fair: moderate gravel; low content of cobble and stone in places.	Unsuitable: excessive fines.	Fair: A–4 and A–6 material; seasonal high water table at a depth of ½ foot to 1½ feet.	Seasonal high water table at a depth of ½ foot to 1½ feet; slow permeability in fragipan.	Poor stability; requires careful compaction.
Hibernia: HbC, HID	Poor: excessive stones, cobbles, and gravel.	Poor: excessive fines; seasonal high water table at a depth of ½ foot to 1½ feet; stones common to numerous.	Good: A–2 and A–4 material; seasonal high water table at a depth of ½ foot to 1½ feet likely to hinder excavations in places; common stones in HbC; numerous stones in HID.	Seasonal high water table at a depth of ½ foot to 1½ feet; slow permeability in fragipan.	Good stability; stones common in HbC; many stones in HID; hazard of erosion at site when removed.
*Holyoke: HoC, HrE For Rock outcrop part of HrE, see Rock outcrop.	Poor: limited material; excessive rocks, stones, and gravel; bedrock at a depth of 1 foot to 1½ feet.	Unsuitable: excessive fines and stones.	Poor: limited material; bedrock at a depth of 1 foot to 1½ feet; steep slopes in HrE.	Hard bedrock at a depth of 1 foot to 1½ feet.	Hard bedrock at a depth of 1 foot to 1½ feet; removal of stones needed.
Klinesville: KlE	Poor: limited material; bedrock at a depth of 1 foot to 1½ feet; high content of shale; severe hazard of erosion on steep slopes.	Unsuitable: no sand or gravel.	Poor: limited material; bedrock at a depth of 1 foot to 1½ feet; severe hazard of erosion on steep slopes.	High seepage losses in fractured shale bedrock.	Limited supply over bedrock at a depth of 1 foot to 1½ feet; severe hazard of erosion on steep slopes.

for engineering purposes—Continued

Soil features affecting—Continued					
Drainage for crops and pasture	Irrigation	Terraces and diversions	Grass waterways	Winter grading	Shallow excavations
Seasonal high water table at surface; rapid permeability.	Rapid intake rate; high available water capacity.	Not applicable	Not applicable	Seasonal high water table at surface.	Seasonal high water table at surface; highly organic material has low bearing capacity.
Seasonal high water table at a depth of 0 to 1 foot; fragipan at a depth of 20 to 30 inches; slow permeability in fragipan; excessive stones in CsB.	Moderate intake rate; seasonal water table at a depth of 0 to 1 foot; drainage needed; excessive stones in CsB.	Not applicable	Not applicable	Seasonal high water table at a depth of 0 to 1 foot; excessive stones in CsB.	Seasonal high water table at a depth of 0 to 1 foot; bedrock generally at a depth of more than 6 feet; excessive stones in CsB.
Not applicable	Moderate intake rate; moderate available water capacity; severe hazard of erosion on EdD.	Hazard of erosion on EdD.	Not applicable	All conditions favorable.	Bedrock generally at at a depth of 6 to 10 feet.
Seasonal high water table at a depth of ½ foot to 4 feet; moderately slow permeability.	Moderate intake rate; moderate available water capacity; seasonal high water table at a depth of ½ foot to 4 feet.	Seasonal high water table at a depth of ½ foot to 4 feet; severe hazard of erosion on EID.	Seasonal high water table at a depth of ½ foot to 4 feet; severe hazard of erosion on EID.	Seasonal high water table at a depth of ½ foot to 4 feet.	Seasonal high water table at a depth of ½ foot to 4 feet.
Seasonal water table perched at a depth of ½ foot to 1½ feet over fragipan; fragipan at a depth of 24 to 36 inches; slow permeability in pan.	Moderate intake rate; moderate available water capacity.	Seasonal high water table at a depth of ½ foot to 1½ feet; fragipan at a depth of 24 to 36 inches.	Seasonal high water table at a depth of ½ to 1½ feet; fragipan at a depth of 24 to 36 inches.	Seasonal high water table at a depth of ½ foot to 1½ feet.	Shale or basalt bedrock generally below a depth of 5 feet; seasonal high water table at a depth of ½ foot to 1½ feet.
Seasonal high water table at a depth of ½ foot to 1½ feet; lateral seepage over fragipan; stones common to numerous.	Moderate intake rate; slow permeability in fragipan; stones common to numerous; seasonal high water table at a depth of ½ foot to 1½ feet; moderately steep slopes in HID.	Seasonal high water table at a depth of ½ foot to 1½ feet; common stones in HbC; numerous stones and moderately steep slopes in HID.	Seasonal water table at a depth of ½ foot to 1½ feet; lateral seepage over fragipan; common stones in HbD; excessive stones in HID.	Seasonal water table at a depth of ½ foot to 1½ feet; lateral seepage over fragipan.	Seasonal water table at a depth of ½ foot to 1½ feet; lateral seepage over fragipan; bedrock generally at a depth of more than 10 feet.
Not applicable	Not applicable; bedrock at a depth of 1 foot to 1½ feet.	Not applicable; hard bedrock at a depth of 1 foot to 1½ feet.	Hard bedrock at a depth of 1 foot to 1½ feet; numerous stones; common rock outcrop.	Hard bedrock at a depth of 1 foot to 1½ feet; common rock outcrop.	Hard bedrock at a depth of 1 foot to 1½ feet; surface stones common to excessive; common rock outcrop.
Not applicable	Not applicable	Not applicable	Bedrock at a depth of 1 foot to 1½ feet.	Steep slopes	Rippable shale bedrock at a depth of 1 foot to 1½ feet; steep slopes.

TABLE 5.—*Interpretations of the soils*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil	Sand and gravel	Road fill	Pond reservoir areas	Dikes and other embankments
Made land: Ma. Material too variable to rate.					
Minoa: MlA, MlB	Good: seasonal high water table at a depth of ½ foot to 1½ feet likely to hinder excavation in winter and spring.	Unsuitable: excessive fines.	Fair: ML, CL material; seasonal high water table at a depth of ½ foot to 1½ feet; high frost-action potential.	Seasonal high water table at a depth of ½ foot to 1½ feet; hazard of seepage in summer.	Poor stability; erodible; poor resistance to piping; poor compaction characteristics.
Muck: Ms, Mu	Poor: water table at surface; highly organic material.	Unsuitable: no sand or gravel.	Unsuitable: highly organic material; low bearing capacity.	Water table at surface more than 8 months.	Unsuitable: poor stability; highly organic material unstable.
Neshaminy: NeB, NeC, NfD.	Poor: excessive gravel and stones; hazard of erosion on NfD.	Unsuitable: excessive fines.	Fair for NeB, NeC: A–4 and A–6 material. Poor for NfD: excessive stones; hazard of erosion.	Hazard of seepage	Good stability; good compaction characteristics for NeB, NeC; excessive stone content in NfD.
Netcong: NtB, NtC	Poor: excessive gravel, cobbles, and stones.	Fair to poor: excessive fines.	Good: A–2 and A–4 material; few stones or boulders in places.	Hazard of seepage	Good stability; excessive stones and boulders in places.
Otisville: OtC, OtD	Poor: excessive sand and gravel.	Good for sand and gravel.	Good: A–1 and A–2 material.	Hazard of seepage	Good stability and bearing strength; porous.
*Parker: PaC, PbD, PeC, PeD, PfE. For Edneyville part of PeC and PeD, see Edneyville series. For Rock outcrop part of PfE, see Rock outcrop.	Poor: excessive gravel, cobbles, and stones.	Poor: excessive fines, cobbles, and stones.	Good for PaC, PbD: hazard of erosion at site if removed. Poor for PeC, PeD, PfE: excessive stones; hazard of erosion on PfE.	Hazard of seepage	Good stability; excessive stone in PeC, PeD, PfE; medium permeability when compacted.
Parsippany: Ph, Pk	Poor: poor drainage limits accessibility to summer months.	Unsuitable: no sand or gravel.	Poor: A–6 and A–7 material; high proportion of plastic fines; moderate shrink-swell potential; poor drainage limits accessibility.	Slow permeability in subsoil; suitable for dug ponds; slow recharge in Ph; rapid recharge in Pk.	Poor stability; moderate shrink-swell potential; high proportion of plastic fines; low permeability when compacted.
Pattenburg: PlB, PlC	Poor: excessive gravel and shale fragments.	Fair for gravel: excessive fines in places; 25 to 60 percent hard siliceous gravel; amount limited by bedrock at a depth of 3½ to 10 feet. Poor for sand: excessive fines.	Fair: A–2 and A–4 material; excessive gravel or shale in places; amount limited by bedrock at a depth of 3½ to 10 feet.	Hazard of seepage in porous bedrock.	Good stability; good compaction characteristics except where shale or gravel is excessive; medium permeability when compacted.

for engineering purposes—Continued

Soil features affecting—Continued					
Drainage for crops and pasture	Irrigation	Terraces and diversions	Grass waterways	Winter grading	Shallow excavations
Seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate intake rate; moderately slow or moderate permeability; high available water capacity; seasonal high water table at a depth of ½ foot to 1½ feet.	Seasonal high water table at a depth of ½ foot to 1½ feet.	Seasonal high water table at a depth of ½ foot to 1½ feet.	Seasonal high water table at a depth of ½ foot to 1½ feet; high capillary action.	Seasonal high water table at a depth of ½ foot to 1½ feet.
Water table at surface more than 8 months; rapid permeability.	Rapid intake rate; rapid permeability; high available water capacity; needs drainage before irrigation.	Not applicable	Not applicable	Water table at surface more than 8 months.	Water table at surface more than 8 months; ditchbanks highly susceptible to collapsing.
Not applicable	Moderate intake rate; moderate permeability; moderate available water capacity; moderately steep slopes and excessive stone content in NfD.	Fair stability; numerous stones in NfD.	Moderately steep slopes and numerous stones in NfD.	Fair trafficability; high capillary action.	Hard bedrock at a depth of 4 to 10 feet; excessive stones in NfD.
Not applicable	Excessive gravel in places; moderate intake rate; moderately rapid permeability; moderate available water capacity.	Excessive gravel in places.	Excessive gravel content in places.	All features favorable.	Few stones or boulders.
Not applicable	Rapid intake rate; low available water capacity; rapid permeability.	Not applicable	Not applicable	Not applicable	Banks readily collapse.
Not applicable	Moderately rapid intake rate; low available water capacity; excessive gravel or stone content in PbD, PeC, PeD, PfE.	Excessive gravel or stone in PbD, PeC, PeD, PfE; excessive slopes in PbD, PeD, PfE.	Excessive gravel or stone in PbD, PeC, PeD, PfE; excessive slopes in PbD, PeD, PfE.	All features favorable.	Stones, boulders, and rocks likely; most abundant on wooded sites and steeper slopes.
Slow permeability; water perched over subsoil; needs filters in places in Pk to prevent plugging of subsurface drains.	Moderately slow intake rate; slow permeability; high available water capacity; needs drainage before irrigation.	Not applicable	Not applicable	Seasonal high water table at a depth of 0 to 1 foot; poor trafficability.	Seasonal high water table at a depth of 0 to 1 foot.
Not applicable	Moderate intake rate; moderate permeability; moderate available water capacity.	Bedrock at a depth of 3½ to 10 feet.	All features favorable.	All features favorable.	Hard or rippable bedrock at a depth of 3½ to 10 feet.

TABLE 5.—*Interpretations of the soils*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil	Sand and gravel	Road fill	Pond reservoir areas	Dikes and other embankments
*Penn: PnB, PnC, PoD. For Klinesville part of PoD, see Klinesville series.	Poor: excessive shale.	Unsuitable: no sand or gravel.	Fair: A–4 and A–6 material; low plasticity index; excessive shale in places; moderate frost-action potential; limited amount above bedrock at a depth of 1½ to 3½ feet.	Hazard of seepage in fractured shale bedrock.	Fair to poor stability; medium permeability when compacted; fair to poor resistance to piping; supply limited by bedrock at a depth of 1½ to 3½ feet.
Pits: Ps. Material too variable to rate.					
Pompton: PtA, PtB	Fair: gravel; seasonal high water table at a depth of ½ foot to 1½ feet.	Poor to a depth of 3 feet: excessive fines; seasonal high water table at a depth of ½ foot to 1½ feet. Fair below a depth of 3 feet.	Fair: seasonal high water table at a depth of ½ foot to 1½ feet; A–2 and A–4 material to a depth of 3 feet; A–2 material below a depth of 3 feet.	Seasonal high water table at a depth of ½ foot to 1½ feet; rapid permeability in substratum; hazard of seepage in summer; suitable for dug ponds.	Fair stability; low permeability when compacted; fair resistance to piping.
Preakness: PvA	Poor: seasonal high water table at a depth of 0 to 1 foot for more than 8 months.	Poor to a depth of 2½ feet: excessives fines; seasonal high water table at a depth of 0 to 1 foot for more than 8 months.	Poor: seasonal high water table at a depth of 0 to 1 foot for more than 8 months.	Seasonal high water table at a depth of 0 to 1 foot for more than 8 months; moderately rapid permeability in substratum; suitable for dug ponds.	Fair stability; needs careful compaction for stability and low permeability.
Preakness variant: Pw	Poor: seasonal high water table at a depth of 0 to 1 foot for more than 8 months.	Poor to a depth of 2½ feet: excessive fines; seasonal high water table at a depth of 0 to 1 foot for more than 8 months.	Poor: seasonal high water table at a depth of 0 to 1 foot for more than 8 months.	Seasonal high water table at a depth of 0 to 1 foot for more than 8 months; moderately rapid permeability in substratum; suitable for dug ponds.	Fair stability; needs careful compaction for stability and low permeability.
Reaville variant: ReB	Poor: excessive shale.	Unsuitable: no sand or gravel.	Fair: A–4 and A–6 material; excessive shale in places.	Seasonal high water table at a depth of ½ foot to 4 feet; hazard of seepage in summer.	Good to poor stability; fair compaction characteristics; excessive shale in places; fair resistance to piping.
Ridgebury: RgA, RlB	Poor: excessive gravel and cobbles; seasonal high water table at a depth of 0 to 1 foot.	Poor: excessive fines, stones, and boulders; seasonal high water table at a depth of 0 to 1 foot.	Poor: excessive stones and boulders; seasonal high water table at a depth of 0 to 1 foot.	Seasonal high water table at a depth of 0 to 1 foot; moderate recharge rate for dug ponds.	Good stability; low permeability; excessive stones and boulders.

for engineering purposes—Continued

Soil features affecting—Continued					
Drainage for crops and pasture	Irrigation	Terraces and diversions	Grass waterways	Winter grading	Shallow excavations
Not applicable	Moderate intake rate; moderately slow permeability; moderate available water capacity; bedrock at a depth of 1½ to 3½ feet; severe hazard of erosion in PoD.	Bedrock at a depth of 1½ to 3½ feet.	Bedrock at a depth of 1½ to 3½ feet.	Fair trafficability	Rippable shale bedrock at a depth of 1½ to 3½ feet.
Moderately rapid permeability; seasonal high water table at a depth of ½ foot to 1½ feet.	Moderately rapid intake rate; moderate available water capacity; seasonal high water table at a depth of ½ foot to 1½ feet; needs drainage before irrigation.	Seasonal high water table at a depth of ½ foot to 1½ feet.	Seasonal high water table at a depth of ½ foot to 1½ feet.	Seasonal high water table at a depth of ½ foot to 1½ feet.	Seasonal high water table at a depth of ½ foot to 1½ feet; ditchbanks readily collapse.
Moderately rapid permeability; seasonal high water table at a depth of 0 to 1 foot.	Moderately rapid intake rate; low or moderate available water capacity; seasonal high water table at a depth of 0 to 1 foot; needs drainage before irrigation.	Not applicable	Not applicable	Seasonal high water table at a depth of 0 to 1 foot for more than 8 months.	Seasonal high water table at a depth of 0 to 1 foot; ditchbanks collapse readily.
Moderately rapid permeability; seasonal high water table at a depth of 0 to 1 foot.	Moderately rapid intake rate; low or moderate available water capacity; seasonal high water table at a depth of 0 to 1 foot; needs drainage before irrigation.	Not applicable	Not applicable	Seasonal high water table at a depth of 0 to 1 foot for more than 8 months.	Seasonal high water table at a depth of 0 to 1 foot; ditchbanks collapse readily.
Seasonal high water table at a depth of ½ foot to 4 feet; moderately slow permeability.	Moderate slow intake rate; moderately slow permeability; high available water capacity.	Seasonal high water table at a depth of ½ foot to 4 feet; excessive shale in places.	Seasonal high water table at a depth of ½ foot to 4 feet; excessive shale in places.	Seasonal high water table at a depth of ½ foot to 4 feet.	Seasonal high water table at a depth of ½ foot to 4 feet; rippable shale bedrock at a depth of 3½ to 5 feet.
Seasonal high water table at a depth of 0 to 1 foot; slow permeability in fragipan.	Moderate intake rate; slow permeability; seasonal high water table at a depth of 0 to 1 foot; needs drainage before irrigation; excessive stones and boulders.	Excessive stones and boulders.	Excessive stones and boulders.	Seasonal high water table at a depth of 0 to 1 foot.	Seasonal high water table at a depth of 0 to 1 foot; ditchbanks readily collapse.

TABLE 5.—*Interpretations of the soils*

Soil series and map symbols	Suitability as a source of—			Soil features affecting—	
	Topsoil	Sand and gravel	Road fill	Pond reservoir areas	Dikes and other embankments
Riverhead: RmA, RmB, RmC.	Poor: excessive gravel.	Good for sand and gravel below a depth of 2 to 3 feet.	Good: A–2 material thick in most places.	Excessive seepage loss in rapidly permeable substratum.	Good stability and compaction characteristics; medium permeability.
Riverhead variant: RnB	Poor: excessive gravel.	Good for sand and gravel below a depth of 2 to 3 feet.	Good: A–2 material thick in most places.	Excessive seepage loss in rapidly permeable substratum.	Good stability and compaction characteristics; medium permeability.
*Rockaway: RoB, RoC, RpC, RrD, RsC, RsD, RsE. For Rock outcrop part of RsC, RsD, and RsE, see Rock outcrop.	Poor: excessive gravel, cobbles, and stones.	Poor: excessive fines, cobbles, stones, and boulders.	Fair for RoB, RoC, and RpC: moderate stone content. Poor for RrD, RsC, RsD, and RsE: high stone content; steep slopes in RsE.	Slow permeability in fragipan.	Good stability; excessive stones and boulders in RpC, RrD, RsC, RsD, RsE, RvF.
*Rock outcrop: Rt, RvF For Rockaway part of RvF, see Rockaway series.	Unsuitable: no material or limited material.	Unsuitable: no sand or gravel.	Unsuitable: little or no sand or gravel.	Steep slopes reduce area of reservoir.	Limited volume of material.
Turbotville: TuA, TuB	Fair: common gravel and stones; seasonal high water table at a depth of ½ foot to 1½ feet.	Unsuitable: excessive fines.	Fair: A–4 and A–6 material; high frost-action potential; seasonal high water table at a depth of ½ foot to 1½ feet.	Seepage excessive in sinkholes in places.	Good to poor stability; low permeability when compacted.
*Urban land: Ua, Ub, Ue, Uh, Uk, Um, Un, Up, UrC, UrD, and Uw. Material too variable to rate. For Edneyville part of Ue, Haledon part of Uh, Neshaminy part of Uk, Penn part of Um, Preakness part of Un, Riverhead part of Up, Rockaway part of UrC and UrD, and Whippany part of Uw, see the respective series.					
Washington: WaB	Good	Unsuitable: excessive fines.	Fair: A–4 and A–6 material; moderate frost-action potential.	Seepage severe in cavernous bedrock in places.	Low permeability when compacted; erodible; good stability.
Whippany: WhA, WhB, WlA, WlB.	Good: seasonal high water table at a depth of ½ foot to 1½ feet.	Unsuitable: no sand or gravel.	Poor: A–6 and A–7 material; moderate shrink-swell potential; high frost-action potential.	Little seepage; seasonal high water table at a depth of ½ foot to 1½ feet.	Poor: moderate shrink-swell potential; good to poor stability; erodible; low permeability.
Whitman: Wm	Poor: excessive stones; seasonal high water table at surface.	Unsuitable: excessive fines.	Poor: seasonal high water table at surface; high frost-action potential.	Low seepage; seasonal high water table at surface.	Excessive stones

for engineering purposes—Continued

Soil features affecting—Continued					
Drainage for crops and pasture	Irrigation	Terraces and diversions	Grass waterways	Winter grading	Shallow excavations
Not applicable	Moderately rapid intake rate; moderate available water capacity.	All features favorable.	All features favorable.	All features favorable.	Ditchbanks readily collapse.
Not applicable	Moderately rapid intake rate; moderate available water capacity.	All features favorable.	All features favorable.	All features favorable.	Ditchbanks readily collapse.
Not applicable	Moderate intake rate; low available water capacity; slow permeability in subsoil; excessive stones and boulders in RpC, RrD, RsC, RsD, RsE, RvF; excessive slopes in RrD, RsD, RsE, RvF.	Excessive stones and boulders in RpC, RrD, RsC, RsD, RsE, RvF; excessive slopes in RrD, RsD, RsE, RvF.	Excessive stones and boulders in RpC, RrD, RsC, RsD, RsE, RvF; excessive slopes in RrD, RsD, RsE, RvF.	All features favorable.	Excessive stones and boulders in RpC, RrD, RsC, RsD, RsE, RvF.
Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Hard rock requires blasting.
Seasonal high water table perched above fragipan at a depth of ½ to 1½ feet; lateral seepage above fragipan.	Moderately slow intake rate; slow permeability in fragipan; seasonal high water table at a depth of ½ foot to 1½ feet; moderate available water capacity.	Slow permeability in fragipan; seasonal high water table at a depth of ½ foot to 1½ feet; lateral seepage over fragipan.	Seasonal high water table at a depth of ½ foot to 1½ feet; lateral seepage over fragipan.	Seasonal high water table at a depth of ½ foot to 1½ feet.	Seasonal high water table at a depth of ½ foot to 1½ feet; limestone bedrock at a depth of 5 to 8 feet or more.
Not applicable	Moderately rapid intake rate; high available water capacity; moderate permeability.	Erodible	Not applicable	Not applicable	Limestone bedrock at a depth of 6 feet or more.
Seasonal high water table perched at a depth of ½ foot to 1½ feet; slow permeability.	Moderately slow intake rate; slow permeability.	Seasonal high water table at a depth of ½ foot to 1½ feet; highly plastic subsoil.	Seasonal high water table at a depth of ½ foot to 1½ feet; high frost-action potential.	Seasonal high water table perched at a depth of ½ foot to 1½ feet.	Seasonal high water table at a depth of ½ foot to 1½ feet; highly plastic subsoil.
Slow permeability in fragipan; excessive stones.	Excessive stones; seasonal high water table at surface.	Not applicable	Not applicable	Seasonal high water table at surface.	Seasonal high water table at surface; excessive stones; sidewalls collapse readily.

TABLE 6.—*Engineering*

[Tests performed by Engineering Department, Rutgers University, in accordance with standard procedures of the American does not

Soil	Site number	Site location		Depth	Mechanical analysis [1]	
		Latitude	Longitude		Percentage passing sieve—	
					¾ in	No. 4 (4.7 mm)
				In		
Bartley loam: (Substratum finer textured than that in modal)	40	40° 49′ 17″	74° 49′ 28″	0–9	99	96
				9–22	100	99
				22–48	94	93
Boonton gravelly loam: (Finer textured than modal)	24	40° 53′ 55″	74° 20′ 52″	0–10	100	97
				10–20	92	90
				20–35	100	98
Califon variant: (Surface layer more sandy than that in modal and more gravelly)	49	40° 47′ 07″	74° 35′ 15″	0–10	90	85
				10–30	88	85
				30–40	100	95
	94	40° 46′ 45″	74° 30′ 50″	0–8	100	94
				8–24	89	84
				24–36	99	95
Edneyville gravelly loam: (Substratum finer textured than that in modal)	92	40° 48′ 02″	74° 33′ 20″	0–8	86	74
				8–20	94	83
				20–45	100	96
				45–64	100	100
Edneyville very stony sandy loam: (Modal)	95	40° 48′ 22″	74° 39′ 35″	0–8	75	72
				8–32	94	88
				32–42	91	86
Ellington variant: (Modal)	68	40° 45′ 06″	74° 27′ 28″	0–8	96	95
				8–17	99	98
				17–27	80	79
Haledon silt loam: (Gravel content higher than that in modal)	21	40° 50′ 48″	74° 23′ 55″	0–8	83	80
				8–18	97	93
				18–40	72	62
				40–144	81	64
Haledon silt loam: (Modal)	28	40° 50′ 24″	74° 27′ 29″	0–11	99	99
				11–20	98	97
				20–34	98	95
Neshaminy gravelly silt loam: (Subsoil more gravelly than that in modal)	87	40° 44′ 02″	74° 29′ 55″	0–8	94	88
				8–19	91	87
				19–34	63	59
Netcong gravelly sandy loam: (Modal)	37	40° 51′ 52″	74° 33′ 40″	0–7	97	92
				7–17	84	79
				17–40	90	86
				40–60	83	76
Otisville gravelly loamy sand: (Surface layer finer textured than that in modal)	69	40° 52′ 50″	74° 25′ 24″	0–7	81	62
				7–16	96	82
				16–204	59	43
				204–240	100	100
Otisville gravelly loamy sand: (Surface layer finer textured than that in modal)	76	40° 54′ 07″	74° 46′ 52″	0–8	93	84
				8–30	40	31
				30–40	64	47
Parsippany silt loam: (Surface layer more gravelly than that in modal)	15	40° 42′ 50″	74° 31′ 10″	0–9	100	100
				9–19	100	100
				19–36	100	100
Parsippany silt loam: (Silt content lower than that in modal)	9	40° 49′ 20″	74° 20′ 35″	0–9	100	99
				9–15	99	95
				15–21	100	99
				21–31	100	99
Parsippany silt loam, sandy loam substratum: (Modal)	14	40° 41′ 57″	74° 29′ 40″	0–7	100	100
				7–17	100	100
				17–42	100	100

test data

Association of State Highway Officials (AASHO) (*1*). Absence of data indicates the determination was not made or information apply]

Mechanical analysis [1]—Continued					Liquid limit	Plasticity index	Moisture density [2]		Classification	
Percentage passing sieve—Continued			Sizes by hydrometer analysis				Maximum dry density	Optimum moisture	AASHO [3]	Unified
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05–0.005 mm	<0.005 mm						
			Pct	*Pct*	*Pct*	*Pct*	*Lb per cu ft*	*Pct*		
92	83	68			43	13			A–7–6(8)	ML
93	82	67	50	15	31	9	104	19	A–4(6)	ML–CL
84	73	59	33	23	32	10	109	17	A–4(5)	ML–CL
80	76	68			34	6			A–4(7)	ML
89	86	78	54	20	32	8	99	18	A–4(8)	ML–CL
97	92	78			25	5	107	13	A–4(8)	ML–CL
81	57	32			39	9			A–2–4(0)	SM
78	69	62	37	13	36	10	104	19	A–4(5)	ML–CL
89	73	60	39	11	28	7	116	13	A–4(5)	ML–CL
88	72	57			32	8			A–4(4)	ML–CL
82	68	56			25	5			A–4(4)	ML–CL
66	54	43			26	5			A–4(2)	SM–SC
65	53	37			42	9			A–5(0)	SM
75	60	46	28	17	28	6	111	15	A–4(2)	SM–SC
88	73	52	26	25	29	7			A–4(3)	ML–CL
98	82	61	36	14	35	7	105	19	A–4(5)	ML
71	48	20			36	7			A–2–4(0)	SM
70	58	36			26	6			A–4(0)	SM–SC
82	67	44				[4] NP			A–4(2)	SM
94	86	58			28	4			A–4(5)	ML–CL
98	87	54			22	4	116	13	A–4(4)	ML–CL
79	67	36			22	5	118	12	A–4(0)	SM–SC
79	71	58			36	12			A–6(6)	ML–CL
68	62	54	25	26	28	8			A–4(4)	ML–CL
54	42	25	13	11	22	9	123	12	A–2–4(0)	SC
54	38	19			[5] NL	NP	125	10	A–1–b(0)	SM
89	84	58			34	8			A–4(5)	ML–CL
97	87	59			25	5	106	17	A–4(5)	ML–CL
81	77	49			24	5	111	14	A–4(3)	SM–SC
76	68	52			40	8			A–4(3)	ML
82	78	73	46	24	32	9			A–4(8)	ML–CL
50	48	44	28	13	33	8			A–4(2)	GM–GC
82	65	40			31	6			A–4(1)	SM–SC
61	50	35			27	5			A–2–4(0)	SM–SC
80	66	49	26	22	26	9	117	14	A–4(3)	SC
69	52	28	14	12	27	7	115	14	A–2–4(0)	SM–SC
51	44	28			37	6			A–2–4(0)	GM–GC
71	33	12			19	NP			A–1–b(0)	SM
39	15	3			NL	NP	117	14	A–1–a(0)	GP
100	98	71			NL	NP	102	16	A–4(7)	ML
77	54	30			28	6			A–2–4(0)	SM–SC
26	7	4			26	5			A–1–a(0)	GP
40	24	4			NL	NP			A–1–a(0)	GP
76	71	59			41	15			A–7–6(7)	ML–CL
83	78	66	30	36	37	12	102	22	A–6(7)	ML–CL
95	92	86	27	57	42	21	102	23	A–7–6(13)	CL
95	76	54			41	9			A–5(4)	ML
77	69	57	27	29	36	12	97	20	A–6(5)	ML–CL
97	87	78	33	45	35	14	101	20	A–6(10)	CL
99	93	84	30	50	40	16	102	22	A–6(11)	ML–CL
91	89	79			46	16			A–7–6(11)	ML–CL
99	98	84	33	48	39	12	100	23	A–6(9)	ML–CL
100	98	47			NL	NP	117	13	A–4(2)	SM

TABLE 6.—*Engineering*

Soil	Site number	Site location		Depth	Mechanical analysis [1]	
		Latitude	Longitude		Percentage passing sieve—	
					¾ in	No. 4 (4.7 mm)
				In		
Parsippany silt loam, sandy loam substratum: (Surface layer less silty than that in modal)	17	40° 46′ 55″	74° 25′ 12″	0–16	98	90
				16–26	100	99
				26–42	100	95
Penn shaly silt loam: (Shale content higher than that in modal)	103	40° 45′ 30″	74° 29′ 12″	0–7	100	91
				7–15	85	50
				15–24	91	69
Penn shaly silt loam: (Silt content lower than that in modal)	104	40° 44′ 50″	74° 28′ 52″	0–2		
				2–10	100	78
				10–20	92	57
Riverhead gravelly sandy loam: (Modal)	75	40° 58′ 15″	74° 21′ 35″	0–14	95	82
				14–34	100	89
				34–42	99	85
Riverhead gravelly sandy loam: (Modal)	26	40° 50′ 37″	74° 27′ 40″	0–9	78	72
				9–18	99	96
				18–45	100	97
Rockaway gravelly sandy loam: (Modal)	25	40° 55′ 11″	74° 25′ 15″	0–10	99	94
				10–18	92	85
				18–36	87	76
Rockaway gravelly sandy loam: (Modal)	30	40° 59′ 28″	74° 21′ 33″	0–15	95	83
				15–27	88	78
				27–60	79	64
Rockaway gravelly sandy loam: (Modal)	29	41° 00′ 06″	74° 27′ 50″	0–11	87	77
				11–25	94	87
				25–66	98	92
Whippany silt loam: (Surface layer contains more gravel than that in modal)	13	40° 42′ 12″	74° 28′ 36″	0–8	100	99
				8–18	100	100
				18–32	100	100

[1] Mechanical analysis according to AASHO Designation: T 88–70 (*1*). Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

Soil properties significant in engineering

Several estimated soil properties significant in engineering are shown in table 4. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties (*3*). Following are explanations of some of the columns in table 4.

Depth to bedrock is the distance from the surface of the soil to the upper surface of the rock layer.

Depth to seasonal high water table is the distance from the surface of the soil to the water table in most years.

Texture is described in table 4 in the standard terms used by the United States Department of Agriculture (USDA). These terms take into account the relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 4 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants (*6*).

test data—Continued

Mechanical analysis [1]—Continued					Liquid limit	Plasticity index	Moisture density [2]		Classification	
Percentage passing sieve—Continued			Sizes by hydrometer analysis				Maximum dry density	Optimum moisture	AASHO [3]	Unified
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05–0.005 mm	<0.005 mm						
			Pct	*Pct*	*Pct*	*Pct*	*Lb per cu ft*	*Pct*		
82	47	30			62	16			A–2–7(1)	SM
99	98	92	46	43	34	14	103	19	A–6(9)	CL
75	71	63	30	28	30	7			A–4(5)	ML–CL
84	69	42			31	5			A–4(2)	SM
48	36	29	12	10	30	9			A–2–4(0)	GM–GC
43	34	22			27	5			A–1–6(0)	GM–GC
62	51	40	27	10	33	7			A–4(1)	GM
42	29	23	13	8	26	7			A–2–4(0)	GM–GC
78	56	22			32	7			A–2–4(0)	SM–SC
81	49	21	15	5	38	7			A–2–4(0)	SM
76	38	17	10	5	28	11			A–2–6(0)	SC
66	53	23			26	5			A–2–4(0)	SM–SC
87	75	26			19	3	118	13	A–2–4(0)	SM
93	78	15			NL	NP	115	13	A–2–4(0)	SM
84	69	39			30	6			A–4(1)	SM–SC
77	63	34			23	6	114	13	A–2–4(0)	SM–SC
71	60	41	24	12	28	10			A–4(1)	SC
75	59	34			25	4			A–2–4(0)	SM–SC
70	58	31			21	6			A–2–4(0)	SM–SC
58	45	21			NL	NP			A–1–b(0)	SM
72	62	35			26	3			A–2–4(0)	SM
80	69	39			18	2			A–4(1)	SM
80	70	38			16	2			A–4(1)	SM
79	71	62			39	10			A–4(5)	ML
100	99	91	45	43	44	20	99	23	A–7–6(13)	CL
100	97	91	45	45	36	14	105	19	A–6(9)	CL

[2] Based on AASHO Designation: T 99–70, Method A (*1*).
[3] Based on AASHO Designation: M 145–66 (*1*).
[4] NP means nonplastic.
[5] NL means nonliquid.

Reaction is the degree of acidity or alkalinity expressed as pH. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils cause damage to building foundations, roads, and other structures.

Engineering interpretations of the soils

The interpretations in table 5 are based on the engineering properties of soils shown in table 4, on test data for soils in this county and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils in Morris County. In table 5, ratings are used to summarize suitability of the soils as a source of topsoil, sand and gravel, and road fill. For the other uses, table 5 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil suitability is indicated by the ratings *good, fair, poor,* and *unsuitable.*

Following are explanations of some of the columns in table 5.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments affect suitability, but also considered in the ratings is damage that will result at the area from which topsoil is taken.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 5 provide

guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is at a depth of less than 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, nor do they indicate quality of the deposit.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and the relative ease of excavating the material at borrow areas.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to permeability and the depth to fractured or permeable bedrock or other permeable material.

Embankments and dikes require soil material that is resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil is unfavorable.

Shallow excavations require digging or trenching to a depth of less than 6 feet, as excavations for pipelines, sewerlines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Drainage for crops and pasture is affected by such soil properties as permeability, texture, and structure; depth to restricting layers or rock; depth to the water table; slope, stability of ditch banks; susceptibility to stream overflow, and availability of outlets for drainage water.

Irrigation of crops is affected by such soil features as available water capacity, rate of water intake, permeability, need for drainage and depth to water table or bedrock, soil texture, content of stones, depth of rooting zone, susceptibility to erosion and stream overflow.

Terraces and diversions are low ridges constructed across the slope to intercept or divert runoff so that it soaks into the soil or flows slowly to a prepared outlet.

Grass waterways are shallow waterways or swales that are kept in grass when the rest of a field is cultivated. They are prepared outlets that provide an erosion-free outlet for runoff water. Such features that affect suitability of a soil for terraces, diversions, or grassed waterways are uniformity and steepness of slopes, depth to bedrock or other unfavorable material, content of stones, permeability, and erosion hazard.

Winter grading is affected chiefly by soil features that are relevant to moving, mixing, and compacting soil when temperatures are below freezing.

Test data

All engineering test data in this report are based on sampling and testing done by Rutgers University, College of Engineering (*5, 8*). Soils were sampled at twenty-four sites in Morris County. The soils sampled were classified according to the current system of classification.

The results of the tests are shown in table 6. Also in table 6, the soil materials are classified according to the Unified and the AASHO systems and the textural classification of the U.S. Department of Agriculture. Names of some of the soils that were sampled in the original engineering study of 1954 were changed to conform with the current soil classification.

Town and Country Planning

This section is mainly for land planners, municipal officials, developers, owners or users of land, and others who are responsible for the preparation or evaluation of land-use plans or for community development. The limitations of the soils for several uses in community developments are given in table 7. The table lists, for each mapping unit, the degree and kinds of limitations for each use named.

A rating of *slight* means soil properties are generally favorable for the rated use, or in other words, limitations that are minor and easily overcome. A rating of *moderate* means that some soil properties are unfavorable but can be overcome by careful planning, design, and good management. A rating of *severe* means soil properties are so unfavorable and so difficult to correct or overcome as to require soil reclamation, special design, or intensive maintenance. Some properties are so unfavorable for a particular use that overcoming the limitations is most difficult and costly and commonly not practical for the rated use.

Planning and zoning officials need to consider the merits of completing uses for soils. Those best for community developments are also among the best for farming. Capability of the soils for farm crops is given at the end of the description for each mapping unit and is explained in the section "Capability Grouping."

Listed in the paragraphs that follow are the uses for which the soils are rated in table 7 and the major soil properties affecting the uses.

Foundations for dwellings. Ratings of the soils for this use are based on the properties of undisturbed soils. Dwellings are three stories or less. Soil ratings are made for buildings with and without basements.

Lawns, landscaping, and golf fairways. Ratings are based on soil properties that affect the growth of plants.

Septic tank absorption fields. This use is considered for residences on normal lot sizes but not for public buildings or trailer parks. Requirements of the New Jersey Department of Health were followed (*7*). Where a seasonal high water table exists, limitations are likely to be more severe than percolation tests indicate if tests are made in dry seasons.

Local roads, streets, and parking lots. These roads, streets, and parking lots are paved. Slope, depth to bedrock, and content of stones and boulders are somewhat more critical for parking lots than for roads because of the more extensive grading required.

Athletic fields. These areas are assumed to be for year round use. If only summer use is planned, limita-

tions resulting from a seasonal high water table are not so severe as is indicated in table 7. These areas are expected to be intensively used and to have a grass turf.

Picnic and play areas. These areas are expected to be in use for about 7 months, April to October. No major land shaping is expected.

Campsites for trailers and tents. These sites are expected to be in use for about 7 months, April to October. If all-season camping is anticipated, limitations resulting from a seasonal high water table are more severe than are indicated in table 7. If possible, in laying out access roads, areas that have a seasonal high water table should be avoided.

Sanitary landfills. Ratings of the soils for this use are based on soil properties to a depth of 5 feet. Onsite investigations are needed to determine soil and water conditions below a depth of 5 feet. Ratings are an indication as to where onsite investigations would be most profitable. Ratings are for trench-type landfills. All soils that have a water table above a depth of 5 feet were rated severe because of the hazard of groundwater pollution. Soils that have small amounts of water perched over a fragipan were rated slight or moderate, depending on the amount of water. Soils that have rapid permeability in the substratum are rated severe because of the hazard of groundwater pollution.

Formation, Morphology, and Classification of the Soils

This section explains how soils form and describes the major horizons in soils. It then describes the system of classifying soils and places the soils in Morris County in the categories of that system.

Formation of the Soils

Soils form through the interaction of five major factors: parent material, climate, plant and animal life, topography, and time. The relative influence of each factor varies from place to place. Local variations in soils in Morris County are caused mainly by differences in kind of parent material and in topography. In places, one factor may dominate the formation of a soil and determine most of its properties.

Parent material

Parent material is the unconsolidated mass in which soils form. It determines the mineralogical and chemical composition of a soil and influences the rate of soil-forming processes.

In Morris County, soils formed in glacial till, glacial outwash, recent stream alluvium, organic material, and rock material weathered in place. The glacial material was left after the glaciers melted 10,000 to 15,000 years ago. Alluvial and organic material is of more recent origin and is still accumulating.

Soils that formed in glacial till are the most extensive and have a wide range of characteristics. A firm substratum is common. Rockaway, Netcong, Boonton, Hibernia, and Haledon soils are examples. Soils that formed in glacial outwash generally have a texture of sandy loam and are underlain by stratified sand and gravel. Examples are Riverhead, Pompton, and Preakness soils. Soils along major streams and in glacial Lake Passaic Basin formed in recent alluvial material. They are the medium-textured to fine-textured Whippany and Parsippany soils and Alluvial land. Carlisle soils formed in organic matter.

Climate

The climate of Morris County is a humid, continental type that is marked by extreme seasonal temperature changes. The county has an annual precipitation of about 44 inches and an average annual air temperature of about 49°F. Rainfall is generally uniform during the growing season, May to September, and averages about 21 inches. The cool temperature and moist conditions promote the accumulation of organic matter in the surface layer. For more detailed information on climate, see the section "Climate."

Plant and animal life

Living organisms are important in soil formation. Plants and animals furnish organic matter to the soil and bring nutrients from lower layers to upper layers. Burrowing insects, such as ants, and other animals are continually mixing the upper layers of the soil. Organic matter plays a major role in determining color. During decomposition it produces organic acids, which accelerate leaching and weathering processes. Bacteria and fungi are active in the decomposition of organic matter, the release of plant nutrients, and the formation of soil structure. When they die, their remains also become a part of the soil.

In Morris County, the native vegetation has greatly influenced soil formation. Man, too, has played a part in soil formation. He has changed the vegetation, removed stones and boulders, and plowed the land. He has added lime and fertilizer, mixed some of the soil horizons, and moved soil material from place to place.

Topography

The shape of the land surface—commonly called the lay of the land—, the slope, and the position in relation to the water table greatly influence the formation of soils. Soils that formed on sloping areas, where runoff is moderate to rapid, generally are well drained; have a bright-colored, unmottled subsoil; and in most places are leached to a greater depth than wetter soils in the same general area. In more gently sloping areas, where runoff is slower, a greater number of soils exhibit some evidence of wetness for short periods, such as mottling in the subsoil. In level areas or slight depressions, where the water table is at or near the surface for long periods, the soils show evidence of wetness to a marked degree. They have a thick, dark-colored, organic surface layer and a strongly mottled or grayish subsoil. The permeability of the soil material, as well as the length, steepness, and configuration of the slopes, influence the kind of soil that forms. Local differences in soils are largely the result of differences in parent material and topography.

TABLE 7.—*Limitations of the soils for*

Soil series and map symbols	Foundations for dwellings—		Lawns, landscaping, and golf fairways	Septic tank absorption fields
	With basement	Without basement		
Adrian: Ad	Severe: frequent flooding; seasonal high water table at surface; low bearing strength.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength.	Severe: seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength.
Alluvial land:				
Ae	Severe: frequent flooding; seasonal high water table at a depth of 2 to 4 feet.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding; seasonal high water table at a depth of 2 to 4 feet.
Am	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.
Annandale:				
AnB	Slight: lateral seepage above fragipan in places.	Slight	Slight	Moderate: slow permeability in fragipan requires deep trenches.
AnC	Moderate: slope; lateral seepage above fragipan in places.	Moderate: slope	Moderate: hazard of erosion.	Moderate: slow permeability in fragipan requires deep trenches.
Bartley:				
BaA, BaB	Moderate: seasonal high table at a depth of 2 to 4 feet.	Slight	Slight	Severe: seasonal high water table at a depth of 2 to 4 feet; slow permeability.
BbC	Moderate: slope increases excavation and land-smoothing costs; hazard of erosion.	Moderate: slope increases excavation and land-smoothing costs.	Moderate: hazard of erosion.	Moderate: slope makes special design and careful installation necessary.
Biddeford: Bd	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.
Boonton:				
BoB	Moderate: seasonal high water table perched over fragipan; lateral seepage over fragipan.	Slight	Moderate: excessive gravel and cobbles.	Moderate: seasonal high water table perched over fragipan; slow permeability in fragipan.
BoC	Moderate: seasonal high water table perched over fragipan; lateral seepage above fragipan.	Slight	Moderate: excessive gravel and cobbles; slope limitation; hazard of erosion.	Moderate: seasonal high water table perched over fragipan; slow permeability in fragipan.

town and country planning

Local roads, streets, and parking lots	Athletic fields	Picnic and play areas	Campsites, trailers, and tents	Sanitary landfill [1]
Severe: frequent flooding; low bearing strength; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength.	Severe: hazard of flooding; low bearing strength; organic material; water table above a depth of 20 inches for 1 month or more during season of use.	Severe: frequent flooding; water table above a depth of 20 inches during season of use; low bearing strength.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength.
Severe: frequent flooding.	Severe: flooding more than once in 2 years during season of use.	Moderate: flooding one or two times for short periods during season of use.	Severe: frequent flooding.	Severe: frequent flooding; seasonal high water table at a depth of 2 to 4 feet.
Severe: frequent flooding; seasonal high water table at surface; high frost-action potential.	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.
Moderate: moderate frost-action potential; stony in places.	Severe: excessive gravel; stony in places.	Slight	Slight	Slight.
Moderate: moderate frost-action potential; stony in places; hazard of erosion.	Severe: excessive gravel; stony in places; slope.	Moderate: slope	Moderate: slope	Slight.
Severe: seasonal high water table at a depth of 2 to 4 feet; high frost-action potential.	Moderate: slow permeability in fragipan; seasonal high water table at a depth of 2 to 4 feet.	Slight	Slight: seasonal high water table below a depth of 30 inches during season of use.	Moderate: seasonal high water table perched over fragipan at a depth of 2 to 4 feet; hazard of pollution where the underlying bedrock is limestone.
Severe: seasonal high water table perched over fragipan at a depth of 2 to 4 feet; high frost-action potential.	Severe: slope; excessive gravel.	Moderate: slope	Moderate: slope	Moderate: seasonal high water table perched over fragipan at a depth of 2 to 4 feet; hazard of pollution where the underlying bedrock is limestone.
Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.	Severe: water table above a depth of 20 inches during season of use.	Severe: frequent flooding; water table above a depth of 20 inches during season of use.	Severe: frequent flooding; seasonal high water table at surface.
Severe: seasonal high water table; high frost-action potential.	Moderate: excessive gravel and cobbles; water table below a depth of 20 inches in all seasons.	Slight	Slight	Slight: seasonal high water table perched over fragipan at a depth of ½ foot to 2½ feet; lateral seepage above fragipan likely in places.
Severe: seasonal high water table; high frost-action potential; slope; hazard of erosion.	Severe: slope	Moderate: slope	Moderate: slope	Slight: seasonal high water table perched over fragipan; lateral seepage over fragipan likely in places; bedrock at a depth of more than 6 feet.

TABLE 7.—*Limitations of the soils for*

Soil series and map symbols	Foundations for dwellings—		Lawns, landscaping, and golf fairways	Septic tank absorption fields
	With basement	Without basement		
BpC	Severe: excessive stones; seasonal high water table perched over fragipan; bedrock at a depth of more than 5 feet.	Moderate: excessive stones; seasonal high water table perched over fragipan.	Severe: excessive stones.	Severe: excessive stones; seasonal high water table perched over fragipan; bedrock at a depth of more than 5 feet.
Califon:				
CaA, CaB, CbB	Severe: seasonal high water table perched at a depth of ½ foot to 4 feet; lateral seepage over fragipan.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet; gravel common in CbB.	Severe: seasonal high water table perched at a depth of ½ foot to 4 feet; lateral seepage above fragipan.
CaC	Moderate: seasonal high water table perched at a depth of ½ foot to 4 feet; lateral seepage over fragipan; strong slopes.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet; strong slopes.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet; gravelly; slope; hazard of erosion.	Severe: seasonal high water table perched at a depth of ½ foot to 4 feet; lateral seepage above fragipan.
CcB, CcC	Moderate: seasonal high water table perched at a depth of ½ foot to 4 feet; lateral seepage above fragipan; high stone content.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet; high stone content.	Severe: high stone content.	Severe: seasonal high water table perched at a depth of ½ foot to 4 feet; lateral seepage above fragipan; very stony.
Califon variant: CdB	Severe: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: moderately well drained and somewhat poorly drained.
Carlisle: Cm	Severe: frequent flooding; seasonal high water table at surface; low bearing strength; severe subsidence.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength; severe subsidence.	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength.
Cokesbury:				
CoA, CoB	Severe: seasonal high water table at a depth of 0 to 1 foot.	Severe: seasonal high water table at a depth of 0 to 1 foot.	Severe: seasonal high water table at a depth of 0 to 1 foot.	Severe: seasonal high water table at a depth of 0 to 1 foot.
CsB	Severe: seasonal high water table at a depth of 0 to 1 foot; extremely stony surface layer.	Severe: seasonal high water table at a depth of 0 to 1 foot; extremely stony surface layer.	Severe: seasonal high water table at a depth of 0 to 1 foot; extremely stony surface layer.	Severe: seasonal high water table at a depth of 0 to 1 foot; extremely stony.
Edneyville:				
EdB	Slight: granite gneiss bedrock at a depth of 6 to 10 feet or more.	Slight	Moderate: moderate gravel.	Slight: granite gneiss bedrock at a depth of 6 to 10 feet or more.
EdC	Moderate: slope	Moderate: slope	Moderate: moderate gravel; slope; hazard of erosion.	Moderate: granite gneiss bedrock at a depth of 6 to 10 feet or more; slope makes special design and careful installation necessary.
EdD	Severe: slope	Severe: slope	Severe: slope; hazard of erosion.	Severe: slope

town and country planning—Continued

Local roads, streets, and parking lots	Athletic fields	Picnic and play areas	Campsites, trailers, and tents	Sanitary landfill [1]
Severe: seasonal high water table; excessive stones.	Severe: excessive stones; seasonal high water table; slope.	Moderate: slope; excessive stones.	Severe: excessive stones.	Severe: excessive stones; seasonal high water table perched over fragipan.
Severe: seasonal high water table at a depth of ½ foot to 4 feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 4 feet.	Slight: water table below a depth of 20 inches during season of use.	Moderate: water table below a depth of 20 inches during season of use.	Moderate: seasonal high water table perched over fragipan at a depth of ½ foot to 4 feet; lateral seepage above fragipan.
Severe: seasonal high water table at a depth of ½ foot to 4 feet; high frost-action potential.	Severe: slope; seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: slope	Moderate: water table below a depth of 20 inches during season of use; slope.	Moderate: seasonal high water table perched over fragipan at a depth of ½ foot to 4 feet; lateral seepage above fragipan.
Severe: seasonal high water table at a depth depth of ½ foot to 4 feet; high frost-action potential.	Severe: high stone content; seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: high stone content.	Moderate: very stony surface layer; water table below a depth of 20 inches during season of use.	Moderate: very stony.
Severe: seasonal high water table at a depth of ½ foot to 4 feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 4 feet; slope.	Slight: water table below a depth of 20 inches during season of use.	Moderate: water table below a depth of 20 inches during season of use.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet.
Severe: frequent flooding; seasonal high water table at surface; low bearing strength; severe subsidence.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength; severe subsidence.	Severe: water table above a depth of 20 inches for 1 month or more during season of use.	Severe: frequent flooding; water table above a depth of 20 inches during season of use.	Severe: frequent flooding; seasonal high water table at surface; highly organic material.
Severe: seasonal high water table at a depth of 0 to 1 foot; high frost-action potential.	Severe: seasonal high water table at a depth of 0 to 1 foot.	Severe: water table above a depth of 20 inches for 1 month or more during season of use.	Severe: water table above a depth of 20 inches during season of use.	Severe: seasonal high water table at a depth of 0 to 1 foot.
Severe: seasonal high water table at a depth of 0 to 1 foot; extremely stony; high frost-action potential.	Severe: seasonal high water table at a depth of 0 to 1 foot; extremely stony.	Severe: water table above a depth of 20 inches for 1 month or more during season of use; extremely stony.	Severe: water table above a depth of 20 inches for 1 month or more during season of use; extremely stony surface layer.	Severe: seasonal high water table at a depth of 0 to 1 foot; extremely stony.
Moderate: moderate frost-action potential.	Severe: excessive gravel.	Slight	Slight	Slight.
Moderate: strong slopes; moderate frost-action potential.	Severe: slope; excessive gravel.	Moderate: slope	Moderate: slope	Slight: granite gneiss bedrock at a depth of 6 to 10 feet or more.
Severe: slope; hazard of erosion.	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.

TABLE 7.—*Limitations of the soils for*

Soil series and map symbols	Foundations for dwellings—		Lawns, landscaping, and golf fairways	Septic tank absorption fields
	With basement	Without basement		
Ellington variant:				
ElB	Moderate: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet.	Severe: moderately slow permeability; seasonal high water table at a depth of ½ foot to 4 feet.
ElC	Moderate: seasonal high water table at a depth of ½ to 4 feet.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet; slope; hazard of erosion.	Severe: seasonal high water table at a depth of ½ foot to 4 feet; moderately slow permeability.
ElD	Severe: steep	Severe: steep	Severe: steep; hazard of erosion.	Severe: steep
Haledon:				
HaB	Severe: seasonal high water table at a depth of ½ foot to 1½ feet; lateral seepage above fragipan.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.
HaC	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high table at a depth of ½ foot to 1½ feet; slope; hazard of erosion.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.
Hibernia:				
HbC	Severe: seasonal high water table perched at a depth of ½ foot to 1½ feet; lateral seepage above fragipan.	Moderate: seasonal high water table perched at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet; stony surface layer.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet; lateral seepage over fragipan.
HlD	Severe: steep; seasonal high water table perched at a depth of ½ foot to 1½ feet.	Severe: steep; seasonal high water table perched at a depth of ½ foot to 1½ feet.	Severe: steep; hazard of erosion.	Severe: steep; seasonal high water table perched at a depth of ½ foot to 1½ feet.
Holyoke:				
HoC	Severe: hard bedrock at a depth of less than 1½ feet.	Severe: hard bedrock at a depth of less than 1½ feet.	Severe: hard bedrock at a depth of less than 1½ feet.	Severe: hard bedrock at a depth of less than 1½ feet.
HrE	Severe: hard bedrock at a depth of less than 1½ feet; steep or very steep; rock outcrop.	Severe: hard bedrock at a depth of less than 1½ feet; steep and very steep; rock outcrop.	Severe: hard bedrock at a depth of less than 1½ feet; steep or very steep; rock outcrop.	Severe: hard bedrock at a depth of less than 1½ feet; steep or very steep; rock outcrop.
Klinesville: KlE	Severe: bedrock at a depth of less than 1½ feet; steep.	Severe: bedrock at a depth of less than 1½ feet; steep.	Severe: bedrock at a depth of less than 1½ feet; steep.	Severe: steep; bedrock at a depth of less than 1½ feet.
Made land: [2] Ma	Severe: uneven settling; gas formation.	Moderate: uneven settling.	Moderate: rooting zone moderately steep.	Severe: variable material at moderate depths.
Minoa: MlA, MlB	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.

town and country planning—Continued

Local roads, streets, and parking lots	Athletic fields	Picnic and play areas	Campsites, trailers, and tents	Sanitary landfill [1]
Severe: seasonal high water table at a depth of ½ foot to 4 feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 4 feet.	Slight: water table below a depth of 20 inches during season of use.	Slight: water table below a depth of 20 inches during season of use.	Severe: seasonal high water table at depth of ½ foot to 4 feet.
Severe: seasonal high water table at a depth of ½ foot to 4 feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 4 feet; slope.	Moderate: slope	Moderate: slope	Severe: seasonal high water table at a depth of ½ foot to 4 feet.
Severe: steep; hazard of erosion; seasonal high water table at a depth of ½ foot to 4 feet; high frost-action potential.	Severe: steep	Severe: steep	Severe: steep	Severe: seasonal high water at a depth of ½ foot to 4 feet.
Severe: seasonal high water table at a depth of ½ foot to 1½ feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: water table above a depth of 20 inches for short periods during season of use.	Severe: water table above a depth of 20 inches during season of use.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet; hard or rippable bedrock at a depth of 5 feet or more.
Severe: seasonal high water table at a depth of ½ foot to 1½ feet; slope; hazard of erosion.	Severe: slope; seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: water table above a depth of 20 inches for short periods during season of use; slope.	Severe: water table above a depth of 20 inches during season of use.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet; hard or rippable bedrock at a depth of 5 feet or more.
Severe: seasonal high water table at a depth of ½ foot to 1½ feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: water table above a depth of 20 inches for short periods during season of use; strong slopes in some places.	Severe: water table above a depth of 20 inches for short periods during season of use; strong slopes in some places.	Severe: seasonal high water table perched at a depth of ½ foot to 1½ feet.
Severe: steep; hazard of erosion; seasonal high water table perched at a depth of ½ foot to 1½ feet; high frost-action potential.	Severe: steep; excessive stones.	Severe: steep	Severe: steep	Severe: seasonal high water table perched at a depth of ½ foot to 1½ feet.
Severe: hard bedrock at a depth of less than 1½ feet.	Severe: hard bedrock at a depth of less than 1½ feet; strong slopes in some places.	Moderate: strong slopes in some places; rock outcrops.	Moderate: strong slopes in some places; rock outcrops.	Severe: hard bedrock at a depth of less than 1½ feet.
Severe: hard bedrock at a depth of less than 1½ feet; steep or very steep; rock outcrop.	Severe: hard bedrock at a depth of less than 1½ feet; steep or very steep; rock outcrop.	Severe: steep or very steep; rock outcrop.	Severe: steep or very steep; rock outcrop.	Severe: hard bedrock at a depth of less than 1½ feet; steep or very steep; rock outcrop.
Severe: steep; bedrock at a depth of less than 1½ feet.	Severe: steep; bedrock at a depth of less than 1½ feet.	Severe: steep	Severe: steep	Severe: steep; bedrock at a depth of less than 1½ feet.
Moderate: uneven settling.	Slight to moderate: coarse fragments; variable thickness of soil covering.	Slight	Slight	Severe: variable material at moderate depths.
Severe: seasonal high water table at a depth of ½ foot to 1½ feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: water table above a depth of 20 inches for short periods during season of use.	Severe: water table above a depth of 20 inches during season of use.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.

TABLE 7.—*Limitations of the soils for*

Soil series and map symbols	Foundations for dwellings—		Lawns, landscaping, and golf fairways	Septic tank absorption fields
	With basement	Without basement		
Muck: Ms, Mu	Severe: frequent flooding; seasonal high water table at surface; low bearing strength; severe subsidence.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength; severe subsidence.	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength.
Neshaminy:				
NeB	Slight: hard bedrock at a depth of more than 6 feet in most places.	Slight	Moderate: gravel	Slight: bedrock at a depth of 6 feet or more in most places; stony in places.
NeC	Moderate: slope; hard bedrock at a depth of 4 to 10 feet or more.	Moderate: slope	Moderate: gravel; slope; hazard of erosion.	Moderate: hard bedrock at a depth of 4 to 10 feet or more; stony in places.
NfD	Severe: steep; excessive stones.	Severe: steep; excessive stones.	Severe: steep; excessive stones.	Severe: steep; excessive stones.
Netcong:				
NtB	Slight	Slight	Moderate: gravel content.	Slight: stony in places; hazard of ground-water pollution.
NtC	Moderate: slope	Moderate: slope	Moderate: gravel content; slope; hazard of erosion.	Moderate: slope makes special design and careful installation necessary.
Otisville:				
OtC	Moderate where slopes are 8 to 15 percent. Slight where slopes are 3 to 8 percent.	Moderate where slopes are 8 to 15 percent. Slight where slopes are 3 to 8 percent.	Severe: coarse texture; low available water capacity; low fertility; low organic-matter content.	Slight where slopes are 3 to 8 percent. Moderate where slopes are 8 to 15 percent; hazard of ground-water pollution.
OtD	Severe: steep	Severe: steep	Severe: coarse texture; low available water capacity; low fertility; low organic-matter content.	Severe: steep slopes; hazard of ground-water pollution.
Parker:				
PaC	Moderate where bedrock is at a depth of 4 to 5 feet. Slight where bedrock is at a depth of 5 to 10 feet; stony in places.	Moderate where slopes are 8 to 15 percent. Slight where slopes are 3 to 8 percent.	Moderate: gravelly and cobbly; stony in places.	Moderate where bedrock is at a depth of 4 to 10 feet. Slight where gently sloping: deep to bedrock; hazard of ground-water pollution.
PbD	Severe: steep	Severe: steep	Severe: steep	Severe: steep
PeC	Moderate: moderate stone content; bedrock at a depth of 4 to 10 feet.	Moderate: moderate stones.	Severe: excessive stones, cobbles, and gravel.	Moderate: moderate stones.
PeD	Severe: steep; moderate stones.	Severe: steep	Severe: steep; excessive stones.	Severe: steep; moderate stones.

town and country planning—Continued

Local roads, streets, and parking lots	Athletic fields	Picnic and play areas	Campsites, trailers, and tents	Sanitary landfill [1]
Severe: frequent flooding; seasonal high water table at surface; low bearing strength; severe subsidence.	Severe: frequent flooding; seasonal high water table at surface; low bearing strength; severe subsidence.	Severe: water table above a depth of 20 inches or more for 1 month during season of use.	Severe: frequent flooding; water table above a depth of 20 inches during season of use.	Severe: frequent flooding; seasonal high water table at surface.
Moderate: moderate frost-action potential.	Severe: excessive gravel.	Moderate: gravel content.	Moderate: gravel content.	Slight to moderate: hard bedrock at a depth of 6 to 10 feet or more.
Moderate: slope; hazard of erosion; moderate frost-action potential; hard bedrock at a depth of 4 to 10 feet.	Severe: slope; excessive gravel.	Moderate: slope; gravel.	Moderate: slope; gravel.	Slight to severe: hard bedrock at a depth 4 to 6 feet or more.
Severe: steep; excessive stones.	Severe: steep	Severe: steep	Severe: steep	Severe: hard bedrock at less than 6 feet in most places.
Slight	Severe: excessive gravel; cobbles.	Moderate: gravel content.	Moderate: gravel content.	Severe: hazard of ground-water pollution.
Moderate: slope; hazard of erosion.	Severe: excessive gravel and cobbles; strong slopes.	Moderate: strong slopes; gravel content.	Moderate: strong slopes; gravel content.	Severe: hazard of ground-water pollution.
Slight where slopes are 3 to 8 percent. Moderate where slopes are 8 to 15 percent.	Severe: coarse texture; low available water capacity; low fertility.	Severe: coarse texture; poor trafficability.	Severe: loose sand; poor trafficability.	Severe: rapid permeability permits groundwater pollution.
Severe: steep	Severe: steep	Severe: steep	Severe: steep	Severe: rapid permeability permits groundwater pollution.
Moderate: strong slopes and stony in places.	Severe: excessive gravel, cobbles, and stones; slope.	Moderate: moderate gravel; strongly sloping to gently sloping.	Moderate: strongly sloping and gently sloping; moderate gravel and cobble.	Severe: insufficient filter material and rapid permeability in C horizon permit hazard of ground-water pollution.
Severe: steep; excessive coarse fragments in places.	Severe: steep	Severe: steep; excessive gravel, cobbles, and stones.	Severe: steep; excessive gravel, cobbles, and stones.	Severe: insufficient filter material and rapid permeability in C horizon permit hazard of ground-water pollution.
Moderate: moderate stones.	Severe: slope; excessive stones.	Moderate: moderate stones.	Moderate: moderate stones.	Severe: excessive stones.
Severe: steep; hazard of erosion; moderate stones.	Severe: steep	Severe: steep	Severe: steep	Severe: excessive stones.

TABLE 7.—*Limitations of the soils for*

Soil series and map symbols	Foundations for dwellings—		Lawns, landscaping, and golf fairways	Septic tank absorption fields
	With basement	Without basement		
PfE	Severe: very steep; rock outcrop.	Severe: very steep; rock outcrop.	Severe: very steep; rock outcrop.	Severe: very steep; rock outcrop.
Parsippany: Ph, Pk	Severe: frequent flooding; seasonal high water table perched at a depth of 0 to 1 foot.	Severe: frequent flooding; seasonal high water table perched at a depth of 0 to 1 foot.	Severe: frequent flooding; seasonal high water table at a depth of 0 to 1 foot.	Severe: frequent flooding; seasonal high water table at a depth of 0 to 1 foot.
Pattenburg:				
PlB	Slight	Slight	Moderate: gravel content.	Slight: hazard of ground-water pollution.
PlC	Moderate: strong slopes.	Moderate: strong slopes.	Moderate: strong slopes; hazard of erosion; gravel content.	Moderate: slope makes special design and careful installation necessary; hazard of ground-water pollution.
Penn:				
PnB	Moderate: rippable shale bedrock at a depth of 1½ to 3½ feet; water perched over bedrock in places for short periods.	Slight: rippable shale bedrock at a depth of 1½ to 3½ feet.	Moderate: bedrock at a depth of 1½ to 3½ feet.	Severe: rippable shale bedrock at a depth of 1½ to 3½ feet.
PnC	Moderate: rippable shale bedrock at a depth of 1½ to 3½ feet; water perched over bedrock in places for short periods.	Moderate: strong slopes; rippable shale bedrock at a depth of 1½ to 3½ feet.	Moderate: bedrock at a depth of 1½ to 3½ feet.	Severe: rippable shale bedrock at a depth of 1½ to 3½ feet.
PoD	Severe: steep; bedrock at a depth of 1 foot to 3½ feet.	Severe: steep; bedrock at a depth of 1 foot to 3½ feet.	Severe: steep; bedrock at a depth of 1 foot to 3½ feet.	Severe: steep; bedrock at a depth of 1 foot to 3½ feet.
Pits:[2] Ps.				
Pompton: PtA, PtB	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth ½ foot to 1½ feet.	Severe: seasonal high water table at a depth ½ foot to 1½ feet.
Preakness: PvA	Severe: frequent flooding; seasonal high water table at a depth of 0 to 1 foot.	Severe: frequent flooding; seasonal high water table at a depth of 0 to 1 foot.	Severe: seasonal high water table at a depth of 0 to 1 foot.	Severe: frequent flooding; seasonal high water table at a depth of 0 to 1 foot.
Preakness variant: Pw	Severe: frequent flooding; seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.	Severe: seasonal high water table at surface.	Severe: frequent flooding; seasonal high water table at surface.
Reaville variant: ReB	Severe: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: seasonal high water table at a depth of ½ foot to 4 feet; shaly surface layer.	Severe: seasonal high water table at a depth of ½ foot to 4 feet.
Ridgebury:				
RgA	Severe: seasonal high water table at a depth of 0 to 1 foot.	Severe: seasonal high water table at depth of 0 to 1 foot.	Severe: seasonal high water table at a depth of 0 to 1 foot; excessive stones.	Severe: seasonal high water table at a depth of 0 to 1 foot.

town and country planning—Continued

Local roads, streets, and parking lots	Athletic fields	Picnic and play areas	Campsites, trailers, and tents	Sanitary landfill [1]
Severe: very steep; rock outcrop.	Severe: very steep; rock outcrop.	Severe: very steep; rock outcrop.	Severe: very steep; rock outcrop.	Severe: very steep; rock outcrop.
Severe: frequent flooding; seasonal high water table at a depth of 0 to 1 foot.	Severe: frequent flooding; seasonal high water table at a depth of 0 to 1 foot.	Severe: water table above a depth of 20 inches during season of use.	Severe: frequent flooding; water table above a depth of 20 inches during season of use.	Severe: frequent flooding; seasonal high water table at a depth of 0 to 1 foot.
Moderate: moderate frost-action potential for SM and SC material.	Moderate: excessive gravel.	Moderate: gravel content.	Moderate: gravel content.	Severe: hazard of ground-water pollution.
Moderate: moderate frost action potential for SM and SC material.	Severe: strong slopes; excessive gravel.	Moderate: strong slopes; gravel content.	Moderate: strong slopes.	Severe: hazard of ground-water pollution.
Moderate: rippable shale bedrock at a depth of 1½ to 3½ feet; moderate frost-action potential.	Moderate: excessive shale; rippable shale bedrock at a depth of 1½ to 3½ feet.	Slight	Slight	Severe: rippable shale bedrock at a depth of 1½ to 3½ feet.
Moderate: rippable shale bedrock at a depth of 1½ to 3½ feet; moderate frost-action potential.	Severe: strong slopes	Moderate: strong slopes; shale content.	Moderate: strong slopes; shale content.	Severe: rippable shale bedrock at a depth of 1½ to 3½ feet.
Severe: steep	Severe: steep	Severe: steep	Severe: steep	Severe: bedrock at a depth of 1 foot to 3½ feet.
Severe: seasonal high water table at a depth of ½ foot to 1½ feet; high frost-action potential.	Severe: seasonal high water table at a depth ½ foot to 1½ feet.	Moderate: water table below a depth of 20 inches during season of use.	Moderate: water table below a depth of 20 inches during season of use.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.
Severe: frequent flooding; seasonal high water table at a depth of 0 to 1 foot.	Severe: seasonal high water table at a depth of 0 to 1 foot.	Severe: water table above a depth of 20 inches for 1 month or more during season of use.	Severe: water table above a depth of 20 inches during season of use.	Severe: seasonal high water table at a depth of 0 to 1 foot.
Severe: frequent flooding; seasonal high water table at surface.	Severe: seasonal high water table at surface.	Severe: water table above a depth of 20 inches for 1 month or more during season of use.	Severe: water table above a depth of 20 inches during season of use.	Severe: seasonal high water table at surface.
Severe: seasonal high water table at a depth of ½ foot to 4 feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 4 feet.	Moderate: water table below a depth of 20 inches during season of use.	Moderate: water table below a depth of 20 inches during season of use.	Severe: seasonal high water table at a depth of ½ foot to 4 feet.
Severe: seasonal high water table at a depth of 0 to 1 foot.	Severe: seasonal high water table at a depth of 0 to 1 foot.	Severe: water table above a depth of 20 inches or more during season of use.	Severe: water table above a depth of 20 inches during season of use.	Severe: seasonal high water table at a depth of 0 to 1 foot.

TABLE 7.—*Limitations of the soils for*

Soil series and map symbols	Foundations for dwellings—		Lawns, landscaping, and golf fairways	Septic tank absorption fields
	With basement	Without basement		
RlB	Severe: seasonal high water table at a depth of 0 to 1 foot; excessive stones.	Severe: seasonal high water table at a depth of 0 to 1 foot; excessive stones.	Severe: seasonal high water table at a depth of 0 to 1 foot; excessive stones.	Severe: seasonal high water table at a depth of 0 to 1 foot; excessive stones.
Riverhead:				
RmA, RmB	Slight	Slight	Slight: gravelly surface layer.	Slight: hazard of ground-water pollution.
RmC	Moderate: slope	Moderate: slope	Moderate: gravelly surface layer; strong slopes; hazard of erosion.	Moderate: strong slopes make special design and careful installation necessary; hazard of ground-water pollution.
Riverhead variant: RnB	Slight	Slight	Moderate: gravelly surface layer.	Slight: hazard of ground-water pollution.
Rockaway:				
RoB	Slight: water perched over fragipan for short periods; stony.	Slight	Moderate: moderate gravel.	Moderate: needs deep ditches in places; lateral seepage above fragipan.
RoC	Moderate: strong slopes; water perched over fragipan may seep laterally.	Moderate: strong slopes.	Moderate: moderate gravel; strong slopes.	Moderate: needs deep ditches in places; lateral seepage above fragipan; slopes make special design and careful construction necessary.
RpC	Moderate: very stony	Moderate: very stony	Severe: excessive stones.	Moderate: very stony
RrD	Severe: excessive stones; steep.	Severe: excessive stones; steep.	Severe: excessive stones; steep.	Severe: excessive stones; steep.
RsC	Severe: rock outcrop; extremely stony.	Severe: rock outcrop; extremely stony.	Severe: rock outcrop; extremely stony.	Severe: rock outcrop; extremely stony.
RsD	Severe: rock outcrop; steep.	Severe: rock outcrop; steep.	Severe: rock outcrop; steep.	Severe: rock outcrop; steep.
RsE	Severe: rock outcrop; very steep.	Severe: rock outcrop; very steep.	Severe: rock outcrop; very steep.	Severe: rock outcrop; very steep.
Rock outcrop: Rt, RvF	Severe: rocky surface layer; steep.	Severe: rocky surface layer; steep.	Severe: rocky surface layer; steep.	Severe: rocky surface layer; steep.
Turbotville: TuA, TuB	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.
Urban land: Ua, Ub. Highly urbanized; present development prohibits other uses.				
Ue	Slight	Slight	Moderate: moderate gravel.	Slight

town and country planning—Continued

Local roads, streets, and parking lots	Athletic fields	Picnic and play areas	Campsites, trailers, and tents	Sanitary landfill [1]
Severe: seasonal high water table at a depth of 0 to 1 foot; excessive stones.	Severe: seasonal high water table at a depth of 0 to 1 foot; excessive stones.	Severe: water table above a depth of 20 inches or more during season of use; excessive stones.	Severe: water table above a depth of 20 inches during season of use; excessive stones.	Severe: seasonal high water table at a depth of 0 to 1 foot; excessive stones.
Slight	Severe: excessive gravel.	Slight	Slight	Severe: hazard of ground-water pollution because of rapid permeability in substratum.
Moderate: strong slopes; hazard of erosion.	Severe: excessive gravel.	Moderate: strong slopes.	Moderate: strong slopes.	Severe: hazard of ground-water pollution because of rapid permeability in substratum.
Slight	Severe: excessive gravel.	Moderate: moderate gravel.	Moderate: moderate gravel.	Severe: hazard of ground-water pollution because of rapid permeability in substratum.
Moderate: moderate frost-action potential.	Severe: excessive gravel.	Moderate: moderate gravel.	Moderate: moderate gravel.	Slight.
Moderate: moderate frost-action potential; strong slopes; hazard of erosion.	Severe: excessive gravel; strong slopes.	Moderate: moderate gravel; strong slopes.	Moderate: moderate gravel; strong slopes.	Slight.
Moderate: very stony; moderate frost-action potential.	Severe: excessive stones; strong slopes in places.	Moderate: very stony; strong slopes in places.	Moderate: very stony; strong slopes in places.	Severe: excessive stones.
Severe: excessive stones; steep.	Severe: excessive stones; steep.	Severe: excessive stones; steep.	Severe: excessive stones; steep.	Severe: excessive stones.
Severe: rock outcrop	Severe: rock outcrop; extremely stony.	Severe: rock outcrop; extremely stony.	Severe: rock outcrop; extremely stony.	Severe: rock outcrop; extremely stony.
Severe: rock outcrop; steep.	Severe: rock outcrop; steep.	Severe: rock outcrop; steep.	Severe: rock outcrop; steep.	Severe: rock outcrop; steep.
Severe: rock outcrop; very steep.	Severe: rock outcrop; very steep.	Severe: rock outcrop; very steep.	Severe: rock outcrop; very steep.	Severe: rock outcrop; very steep.
Severe: rocky surface layer; steep.	Severe: rocky surface layer; steep.	Severe: rocky surface layer; steep.	Severe: rocky surface layer; steep.	Severe: rocky surface layer; steep.
Severe: seasonal high water table at a depth of ½ foot to 1½ feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: water table below a depth of 20 inches for short periods.	Moderate: water table below a depth of 20 inches during season of use.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.
Moderate: moderate frost-action potential.	Moderate: moderate gravel.	Moderate: moderate gravel.	Moderate: moderate gravel.	Slight.

TABLE 7.—*Limitations of the soils for*

Soil series and map symbols	Foundations for dwellings—		Lawns, landscaping, and golf fairways	Septic tank absorption fields
	With basement	Without basement		
Uh	Severe: seasonal water table moderately high.	Moderate: seasonal water table moderately high.	Moderate: seasonal water table moderately high.	Severe: seasonal water table moderately high.
Uk	Slight: hard bedrock at a depth of more than 6 feet in most places.	Slight	Moderate: gravel content.	Slight: bedrock at a depth of more than 6 feet in most places.
Um	Severe: depth to bedrock.	Moderate: depth to bedrock.	Severe: depth to bedrock.	Severe: depth to bedrock.
Un	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.
Up	Moderate: gently sloping to steep.	Moderate: gently sloping to steep.	Moderate: moderate gravel; strongly sloping to steep in some places.	Moderate: strongly sloping to steep in some places; hazard of ground-water pollution.
UrC	Moderate: gently sloping and strongly sloping.	Moderate: gently sloping and strongly sloping.	Moderate: moderate gravel and stones.	Moderate: strongly sloping in some places.
UrD	Severe: steep	Severe: steep	Severe: steep	Severe: steep
Uw	Severe: seasonal water table moderately high.	Moderate: seasonal water table moderately high.	Moderate: seasonal water table moderately high.	Severe: seasonal water table moderately high.
Washington: WaB	Slight	Slight	Slight	Slight: hazard of ground-water pollution where bedrock is cavernous.
Whippany: WhA, WhB, WlA, WlB.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: seasonal high water table at a depth of ½ foot to 1½ feet.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.
Whitman: Wm	Severe: seasonal high water table at surface.	Severe: seasonal high water table at surface.	Severe: seasonal high water table at surface.	Severe: seasonal high water table at surface.

[1] Onsite investigations needed to determine soil and water table conditions below a depth of 5 feet.
[2] Material variable; onsite investigation needed.

Time

The formation of soils generally requires a long time for changes to take place in the parent material. The soils in northern Morris County formed since glaciation. Soils in southern Morris County are much older and have, therefore, a thicker and more completely weathered profile.

Morphology of the Soils

This section contains a brief description of the nomenclature of soil horizons. It also provides information about the development of horizons.

Major horizons

The results of the soil-forming factors can be distinguished by the different layers, or horizons, seen in a soil profile. The profile extends from the surface of the soil downward to material that is little altered by the soil-forming processes.

Most soils contain three major horizons, A, B, and C. These major horizons can be further subdivided by the use of letters to indicate specific kinds of horizons.

The A horizon is at or near the surface. It has an accumulation of organic matter or represents the zone of maximum leaching.

town and country planning—Continued

Local roads, streets, and parking lots	Athletic fields	Picnic and play areas	Campsites, trailers, and tents	Sanitary landfill [1]
Severe: seasonal water table moderately high; high frost-action potential.	Severe: seasonal water table moderately high.	Moderate: water table below a depth of 20 inches during season of use.	Moderate: water table below a depth of 20 inches during season of use.	Severe: seasonal water table moderately high.
Moderate: moderate frost-action potential.	Severe: excessive gravel.	Moderate: gravel content.	Moderate: gravel content.	Moderate: hard bedrock at a depth of 6 to 10 feet in most places.
Moderate: depth to bedrock.	Severe: excessive shale.	Moderate: moderate shale.	Moderate: moderate shale.	Severe: insufficient depth to bedrock.
Severe: seasonal high water table; high frost-action potential.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.	Severe: seasonal high water table.
Moderate: gently sloping to steep.	Severe: gently sloping to steep; excessive gravel.	Moderate: excessive slopes in places; moderate gravel.	Moderate: excessive slopes in places; moderate gravel.	Severe: rapid permeability in substratum; hazard of ground-water pollution.
Moderate: moderate frost-action potential; strongly sloping in some places.	Severe: excessive gravel and stones; strongly sloping in some places.	Moderate: moderate gravel and stones; strongly sloping in some places.	Moderate: moderate gravel and stones; strongly sloping in some places.	Slight: excessive stones in some places.
Severe: steep	Severe: steep	Severe: steep	Severe: steep	Moderate: steep; excessive stones in places.
Severe: seasonal water table moderately high; high frost-action potential.	Severe: seasonal water table moderately high.	Moderate: water table above a depth of 20 inches for short periods during season of use.	Moderate: water table above a depth of 20 inches for short periods during season of use.	Severe: seasonal water table moderately high.
Moderate: moderate frost-action potential; bedrock cavernous in places.	Moderate: slope	Slight	Slight	Slight to severe: severe where bedrock is cavernous.
Severe: seasonal high water table at a depth of ½ foot to 1½ feet; high frost-action potential.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.	Moderate: water table above a depth of 20 inches for short periods during season of use.	Severe: water table above a depth of 20 inches during season of use; slow permeability.	Severe: seasonal high water table at a depth of ½ foot to 1½ feet.
Severe: seasonal high water table at surface; high frost-action potential.	Severe: seasonal high water table at surface.	Severe: water table above a depth of 20 inches during season of use.	Severe: water table above a depth of 20 inches during season of use.	Severe: seasonal high water table at surface; very stony.

The A1 and Ap horizons are at the surface and have an accumulation of organic matter. The A2 horizon is beneath the surface and represents a zone of leaching. In Morris County the A2 horizon is typically paler in color than the A1, Ap, or underlying B horizons.

The B horizon is underneath the A horizon and is commonly called the subsoil. The B horizon represents the zone of accumulation of material leached from the A horizon or formed in place as a result of weathering. Most soils in Morris County have a B horizon in which clays and associated oxides of iron and aluminum, leached from the A horizon, have accumulated. Such a horizon is called a B2t horizon, as in soils in the Annandale series. A firm, dense, slowly permeable layer in the subsoil is a Bx horizon, which occurs in the Annandale soils. Other horizons have formed within the B horizon, largely by weathering of and alteration of material in place. The weathering may be due to oxidation or reduction of iron or to the weathering of clay minerals. The B horizon is generally firmer, has a blocky or prismatic structure, and is generally firmer and lighter colored than the A horizon but darker colored than the C horizon. Most younger soils have a weakly developed B horizon.

The C horizon is below the A or B horizons. It consists of material that is little altered by the soil-forming processes but may be modified by weathering. The C horizon is commonly called parent material.

Processes of soil horizon differentiation

Several processes are involved in the differentiation of soil horizons in the soils of Morris County. These include the accumulation of organic matter, the leaching of soluble salts, reduction and translocation of iron, the formation of structure, and some translocation and loss of clay minerals, aluminum, silica, and iron. These processes are continually taking place and generally at the same time throughout the profile. These processes are timed in thousands of years.

The accumulation of organic matter takes place with the decomposition of plant residue. This process darkens the surface layer and helps form the A1 horizon. Organic matter, once it has been lost, takes a long time to replace.

Most of the soils in Morris County have a distinct subsoil. It is believed that some of the lime and other soluble salts were leached before the translocation of iron and clay took place. Such factors as the kinds of salt originally present, the depth to which the soil solution percolates, and the texture of the profile all affect leaching.

Well drained and moderately well drained soils in Morris County have a yellowish-brown or reddish-brown subsoil. These colors are mainly caused by thin coatings of iron oxides on sand and silt grains. Weak to moderate development of subangular blocky structure has taken place, but the subsoil contains the same or slightly more clay than the overlying surface layer.

The reduction and transfer of iron is associated mainly with the wetter, more poorly drained soils. This process is called gleying. Poorly drained to very poorly drained soils, such as Parsippany, Whitman, and Preakness soils, have a subsoil and underlying material that are grayish colored, indicating reduction and transfer of iron. Moderately well drained to somewhat poorly drained soils have yellowish-brown, reddish-brown, and gray mottles, which indicate the segregation of iron.

A fragipan developed in the subsoil of many moderately well drained and somewhat poorly drained soils. This horizon is very firm and brittle when moist and hard when dry. Soil particles are tightly packed so that bulk density is high and pore space is low. Genesis of these horizons is not fully understood, but studies show that swelling and shrinking take place in alternating wet and dry periods. This may account for the tight packing of soil particles and also a gross polygonal pattern of cracks in the fragipan. Clay, silica, and oxides of aluminum are the most likely cementing agents that cause brittleness and hardness.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965 (*11*). Because this system is under continual study, readers interested in developments of the current system should search the latest literature available.

The current system of classification has six categories. Beginning with the broadest, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that soils of similar genesis, or mode of origin, are grouped. In table 8, the soil series of Morris County are placed in some categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

Orders.—Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Inceptisol).

Suborders.—Each order is divided into suborders based primarily on those soil characteristics that seem to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences that result from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquept* (*Aqu,* meaning water or wet, and *ept,* from Inceptisol).

Great groups.—Soil suborders are divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus has accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is *Fragiaquepts* (*Fragi,* meaning brittle hori-

TABLE 8.—*Classification of soil series and selected land types*

Series	Family	Subgroup	Order
Adrian	Sandy or sandy-skeletal, mixed, euic, mesic	Terric Medisaprists	Histosols.
Alluvial land	Unclassified	Aquents and Ochrepts [1]	Entisols and Inceptisols.
Alluvial land, wet	Unclassified	Fluvaquents [1]	Entisols.
Annandale	Fine-loamy, mixed, mesic	Typic Fragiudults	Ultisols.
Bartley	Fine-loamy, mixed, mesic	Typic Fragiudalfs	Alfisols.
Biddeford [2]	Fine, illitic, nonacid, mesic	Histic Humaquepts	Inceptisols.
Boonton	Coarse-loamy, mixed, mesic	Typic Fragiudalfs	Alfisols.
Califon	Fine-loamy, mixed, mesic	Typic Fragiudults	Ultisols.
Califon variant	Fine-loamy, mixed, mesic	Aquic Hapludults	Ultisols.
Carlisle	Euic, mesic	Typic Medisaprists	Histosols.
Cokesbury	Fine-loamy, mixed, mesic	Typic Fragiaquults	Ultisols.
Edneyville	Fine-loamy, mixed, mesic	Typic Hapludults	Ultisols.
Ellington variant	Coarse-loamy, mixed, mesic	Aquic Dystrochrepts	Inceptisols.
Haledon	Coarse-loamy, mixed, mesic	Aquic Fragiudalfs	Alfisols.
Hibernia	Coarse-loamy, mixed, mesic	Aquic Fragiudults	Ultisols.
Holyoke	Loamy, mixed, mesic	Lithic Dystrochrepts	Inceptisols.
Klinesville	Loamy-skeletal, mixed, mesic	Lithic Dystrochrepts	Inceptisols.
Minoa	Coarse-loamy, mixed, mesic	Aquic Dystric Eutrochrepts	Inceptisols.
Muck	Unclassified	Medisaprists and Medihemists [1]	Histosols.
Neshaminy	Fine-loamy, mixed, mesic	Ultic Hapludalfs	Alfisols.
Netcong	Coarse-loamy, mixed, mesic	Ruptic-Ultic Dystrochrepts	Inceptisols.
Otisville	Sandy-skeletal, mixed, mesic	Typic Udorthents	Entisols.
Parker	Loamy-skeletal, mixed, mesic	Typic Dystrochrepts	Inceptisols.
Parsippany	Fine, mixed, mesic	Aeric Ochraqualfs	Alfisols.
Pattenburg	Loamy-skeletal, mixed, mesic	Typic Hapludults	Ultisols.
Penn	Fine-loamy, mixed, mesic	Ultic Hapludalfs	Alfisols.
Pompton	Coarse-loamy, mixed, mesic	Aquic Dystrochrepts	Inceptisols.
Preakness	Coarse-loamy, mixed, acid, mesic	Typic Humaquepts	Inceptisols.
Preakness variant	Sandy, mixed, acid, mesic	Histic Humaquepts	Inceptisols.
Reaville variant	Fine-loamy, mixed, mesic	Aquic Hapludalfs	Alfisols.
Ridgebury	Coarse-loamy, mixed, mesic	Aeric Fragiaquepts	Inceptisols.
Riverhead	Coarse-loamy, mixed, mesic	Typic Dystrochrepts	Inceptisols.
Riverhead variant	Coarse-loamy, mixed, mesic	Dystric Eutrochrepts	Inceptisols.
Rockaway	Coarse-loamy, mixed, mesic	Typic Fragiudults	Ultisols.
Turbotville	Fine-loamy, mixed, mesic	Aquic Fragiudalfs	Alfisols.
Washington	Fine-loamy, mixed, mesic	Ultic Hapludalfs	Alfisols.
Whippany	Fine, mixed, mesic	Aquic Hapludalfs	Alfisols.
Whitman	Coarse-loamy, mixed, mesic	Typic Fragiaquepts	Inceptisols.

[1] Classification is at the great group level instead of subgroup.
[2] These soils are taxadjuncts to the Biddeford series. They are outside the defined range for the series in having redder colors and mixed mineralogy.

zons, *aqu* for wetness or water, and *ept,* from Inceptisols).

Subgroups.—Great groups are divided into subgroups, one that represents the central (typic) segment of the group and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is *Aeric Fragiaquepts* (better aerated than typical).

Families.—Subgroups are divided into families primarily on the basis of properties important to the growth of plants or of the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae (see table 8). An example is the coarse-loamy, mixed, mesic family of Aeric Fragiaquepts.

Relationship of Soil Series

In table 9 the soil series of Morris County are grouped to show the relationship of parent material and natural drainage under which the soils formed.

Geology

Most of Morris County north and west of a line extending from Bernardsville through Morristown, Boonton, and Riverdale is in the Appalachian Highlands and is underlain by Precambrian gneissic bedrock (*5*). This part of the county is typically mountainous. It has broad, rounded or flat-topped ridges. The average elevation is 1,000 feet but ranges to as much as 1,388 feet. Narrow valleys are 300 to 600 feet below the ridges. These valleys are mostly related to faulting and are underlain by limestone, sandstone, or shale bedrock.

TABLE 9.—*Soil series arranged to show relationship between parent material and drainage*

Parent material	Excessively drained	Well drained	Moderately well drained	Somewhat poorly drained	Poorly drained	Very poorly drained
Glacial till deposits:						
Weathered to a depth of 12 to 20 inches: Gravelly to extremely stony silt loams formed in till derived mainly from basalt and red shale.		Holyoke				
Weathered to a depth of 20 to 40 inches: Gravelly to extremely stony sandy loams formed in till derived mainly from granitic gneiss.		Rockaway	Rockaway	Hibernia	Ridgebury	Whitman.
Weathered to a depth of 30 to 50 inches: Gravelly to stony sandy loams formed in till derived mainly from granitic gneiss.		Netcong		Hibernia	Ridgebury	
Weathered to a depth of 40 to 60 inches: Gravelly to extremely stony loams or silt loams formed in till derived mainly from red shale and basalt.			Boonton	Haledon		
Loams and gravelly to extremely stony loams formed in strongly weathered till derived mainly from granitic gneiss.		Annandale	Califon	Califon	Cokesbury	
Loams or gravelly loams formed largely in strongly weathered till derived mainly from granitic gneiss but in places from limestone residuum in the lower part.		Washington	Bartley	Turbotville		
Glacial outwash deposits:						
Weathered to a depth of 14 to 24 inches: Gravelly loamy sands formed in outwash derived mainly from granitic gneiss.	Otisville					
Weathered to a depth of 24 to 40 inches: Gravelly sandy loams formed in outwash derived mainly from granitic gneiss but with an admixture of limestone.		Riverhead variant.				
Weathered to a depth of 20 to 50 inches: Gravelly sandy loams formed in outwash derived mainly from granitic gneiss.		Riverhead		Pompton	Preakness	Preakness variant.
Old beach deposits:						
Weathered to a depth of 20 to 30 inches: Fine sandy loams formed in old beach deposits derived from red shale, siltstone, and sandstone.			Ellington variant.	Ellington variant.		
Lacustrine deposits:						
Weathered to a depth of 24 to 50 inches: Soils formed in stratified silty and clayey sediments.				Whippany	Parsippany	Biddeford.
Soils formed in stratified silty and sandy sediments.				Minoa		
Residuum from underlying rock:						
Weathered to a depth of 10 to 20 inches: Shaly silt loams formed in residuum of red shale or siltstone.		Klinesville				
Weathered to a depth of 20 to 60 inches: Shaly silt loams formed in residuum of red shale or siltstone.		Penn	Reaville variant.	Reaville variant.		
Gravelly loams formed in residuum of red conglomerate rock.		Pattenburg				

TABLE 9.—*Soil series arranged to show relationship beween parent material and drainage*—Continued

Parent material	Excessively drained	Well drained	Moderately well drained	Somewhat poorly drained	Poorly drained	Very poorly drained
Gravelly to very stony silt loams formed in residuum of basalt.		Neshaminy				
Gravelly to extremely stony sandy loams or loams formed in residuum or colluvium of granitic gneiss.	Parker	Edneyville	Califon variant.	Califon variant.	Cokesbury	
Organic deposits: Organic soils 15 to 50 inches deep over a mineral substratum:						
Muck underlain by sand or loamy sand.						Adrian.
Muck underlain by clay						Muck, shallow over clay.
Muck underlain by loam, silt loam, or silty clay loam.						Muck, shallow over loam.
Organic soils more than 50 inches thick						Carlisle.
Recent alluvial deposits			Alluvial land.	Alluvial land.	Alluvial land.	Alluvial land, wet.

The rest of the county, southeast of a line from Bernardsville to Riverdale, is in the Piedmont Plateau or lowlands. It is mostly underlain by soft red shale or sandstone bedrock. Within this zone are two prominent ridges, Long Hill and Hook Mountain, which are outcrops of hard, dark-colored basalt bedrock.

The gneissic bedrock in the Appalachian Highlands has mixed mineralogy of oligoclase, quartz, and lesser amounts of orthoclase, hornblende, and biotite. It is mainly coarse grained to very coarse grained. When it weathers, the hard quartz grains remain as medium to coarse, angular sand grains, which give the loamy soils that formed in this material a gritty feel.

Brunswick Shale (*4*), the dominant formation in the Piedmont lowlands, is a soft red shale or siltstone that is interbedded with sandstone. The soils that formed in this material contain a high proportion of weathered shale and consist mostly of silt or fine sand.

The basalt is a fine-grained traprock that is nearly devoid of quartz and other resistant minerals. On weathering, the basalt gives the soils a silt loam or sandy loam texture.

Morris County has been subject to repeated periods of glaciation. The glaciers have scoured the northern part of the county to bare rock in many places, deposited glacially mixed and transported material over much of the county, and altered the drainage pattern. Glacial deposits of at least three different ages (*9*) exist in the county today (*9*). The oldest are deeply and intensively weathered, but they are so eroded that only remnants remain. Califon, Annandale, and Cokesbury soils on top of Schooley's Mountain are among the soils that formed in the oldest glacial deposit. These soils have strongly expressed horizons.

The intermediate-aged glacial deposits are more sandy, less clayey, and otherwise less deeply and intensively weathered than the older deposits. Netcong soils, which formed in these deposits, have less strongly expressed horizons than those of soils that formed in older deposits.

The youngest and most extensive area of glacial deposits is in the northern half of Morris County, north of a line from Hackettstown to Dover, Morris Plains, Morristown, and Chatham. These deposits are only thinly and slightly weathered. Rockaway, Hibernia, Haledon, and Boonton soils that formed in these comparatively recent deposits have weakly expressed horizons.

In addition to being of different age, the deposits in the county also have different composition. In most of Morris County, in that area underlain by gneissic bedrock, the glacial deposits are largely granitic material; in the eastern part of the county, they are mainly shale and traprock material. Between the two extremes in composition are deposits that are a mixture of both kinds of material.

Glacial outwash deposits also occur. The Riverhead series is an example of a soil that formed in the slightly weathered, gravelly and sandy, stratified material in such deposits.

During the most recent period of glaciation, and probably during the early periods as well, a large lake known as Glacial Lake Passaic was formed in the Piedmont lowlands. It was bounded by the highlands to the northwest; the Watchung Mountains to the southwest, south, and east; and the glacial ice to the north. During the time when this area was a lake, glacial melt water deposited fine-textured sediment on the bottom of the lake. As the ice melted and an outlet developed, the lake drained, leaving a nearly level basin of mainly silty and

clayey material. Whippany and Parsippany soils formed in this material.

Included within the formerly glaciated areas are hundreds of kettles, or basins. These kettles were filled progressively as organic material, and mineral sediment accumulated in them. Carlisle and Adrian soils formed in these present-day lakes, ponds, shallow marshy areas, and bogs.

Neshaminy, Penn, Edneyville, and Parker soils are examples of soils that formed mainly in material weathered from the underlying bedrock that has been subject to little or no glacial influence. For the most part, the material is old and deeply weathered. The soils have strongly expressed horizons. On the steeper slopes, where erosion removes weathered material almost as fast as it forms, the soils are characteristically stony and moderately deep.

Climate[5]

Morris County, although humid and temperate, has a continental climate that has very little influence from the ocean. The data on temperature and precipitation shown in table 10 are mostly from the cooperative weather station at Morris Plains, and the data on frosts shown in table 11 are from the cooperative station at Boonton.

Temperature in summer seldom exceeds 100° F, but temperature in the middle or upper 90's does occur frequently. Winter temperature is generally not below 10° F for long periods, but is low enough that farm drainage tile must be placed below a depth of 30 inches for protection against freezing.

On the average, annual precipitation ranges from about 46 to 49 inches throughout the county, and the monthly averages show that precipitation is well distributed throughout the year. Nearly every year, however, there are periods when rainfall is not sufficient for high-value crops. Consequently, the irrigated acreage has increased considerably in recent years, especially during the drought of 1961–66. Rainfall is heaviest in July and in August. Much of this rainfall in summer accompanies thunderstorms—about 33 per year. Between 11 and 16 inches of rain fell in the county in August 1955, in connection with the passage of two hurricanes and some thunderstorms.

The average length of the growing season in the county is about 159 days. The average date of the last killing freeze in spring is May 2, and that of the first in fall is October 8. Probabilities for the last damaging cold temperature in spring and the first in fall are listed in table 11.

As a rule, temperature in winter is not low enough to keep the ground frozen throughout the season. Rainfall during winter frequently warms the soil enough to thaw it to a depth of several inches. Heavy rainfall causes the partly thawed soils to be very erodible. Hail is not frequent, but it can be destructive to high-value crops.

[5] Prepared by DONALD V. DUNLAP, climatologist for New Jersey, National Weather Service, U.S. Department of Commerce.

TABLE 10.—*Temperature and precipitation data*

[Data mainly from Morris Plains; data on snow cover are a composite record from three stations]

Month	Temperature				Precipitation				
			Two years in 10 will have at least 4 days with:			One year in 10 will have:			
	Average daily high	Average daily low	High temperature equal to or higher than—	Low temperature equal to or lower than—	Average monthly total	Less than—	More than—	Days that have snow cover of 1 inch or more	Average depth of snow on days that have snow cover
	°F	°F	°F	°F	In	In	In	In	In
January	38	20	55	1	3.1	1.5	5.6	13	5
February	40	20	57	4	2.9	1.8	4.5	12	8
March	46	30	64	21	4.2	2.5	7.4	8	6
April	61	38	79	27	4.1	2.2	7.0	1	3
May	72	46	86	35	4.5	1.7	6.5	0	0
June	77	55	94	44	3.6	1.5	6.8	0	0
July	85	61	96	51	4.3	1.2	7.6	0	0
August	83	59	91	48	5.2	1.7	9.7	0	0
September	76	52	89	38	3.9	1.3	6.4	0	0
October	67	41	80	30	3.4	1.0	6.9	(1)	1
November	53	33	67	22	4.5	2.2	7.2	1	2
December	41	22	57	6	4.1	1.2	5.7	9	3
Year	62	40	[2] 96	[3] −4	47.8	35.1	59.4	44	5

[1] Less than 0.5 day.

[2] Average annual highest temperature.

[3] Average annual lowest temperature.

TABLE 11.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data from Boonton]

Probability	Dates for given probability and temperatures				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	April 5	April 13	April 23	May 7	May 22
2 years in 10 later than	March 26	April 3	April 15	April 30	May 15
5 years in 10 later than	March 11	March 19	April 1	April 17	May 2
Fall:					
1 year in 10 earlier than	November 18	November 6	October 19	October 10	September 27
2 years in 10 earlier than	November 24	November 12	October 24	October 14	October 1
5 years in 10 earlier than	December 4	November 23	November 4	October 23	October 8

Farming

The pressure of residential, industrial, and commercial land development is rapidly changing the character of land use in Morris County. Much of the county is now characterized by country estates and part-time farms, the homes of persons whose main interests lie in the nearby cities where they commute to work. Farming is complex and technical, and emphasis is placed on obtaining the highest possible yield per acre. Assistance in planning current or future use of the soils can be obtained from representatives of the Morris County Soil Conservation District, the Soil Conservation Service, the Agricultural Extension Service, and other organizations that maintain offices in the county.

In 1964 about 36,087 acres, or 12 percent of the county, was in farms; by 1969 the acreage dropped to about 29,114 acres, or 9.7 percent of the county. The average size of a farm was 85.7 acres in 1964 and 90.1 acres in 1969. The following tabulation shows the use of farmland in 1964 and 1969.

	1964 Acres	1969 Acres
Total cropland	20,102	16,037
Harvested cropland	13,663	9,757
Cropland used only for pasture or grazing	2,953	3,705
All other cropland	3,486	2,575
Woodland including woodland pasture	8,481	9,099

In 1969, 6,300 acres of hay was harvested, 1,550 acres of corn, 500 acres of sweet corn, 300 acres of cabbage, 150 acres of lettuce, 150 acres of tomatoes, and 150 acres of peppers.

Literature Cited

(1) American Association of State Highway Officials. 1961. Standard specifications for highway materials and methods of sampling and testing. Ed. 8, 2 v., illus.

(2) Geological Survey of New Jersey. 1899. Report of forests. Annual Report of the State Geologist. 327 pp., illus.

(3) Jumikis, Alfred R. 1959. Engineering aspects of glacial soils of the Newark metropolitan area of New Jersey. Eng. Research Bull. 42, Col. of Eng., Rutgers U., 72 pp., illus.

(4) Kümmel, Henry B. 1940. The geology of New Jersey. N.J. Dept. of Conserv. and Devlpmt. Bull. 50, 203 pp., illus.

(5) Minard, James P., Holman, William W., and Jumikis, Alfred R. 1953. Engineering soil survey of New Jersey, report number 9, Morris County. Eng. Research Bull. 23, Col. of Eng., Rutgers U., 86 pp., illus.

(6) New Jersey Agricultural Experiment Station, Rutgers University. [n.d.] Sprinkler irrigation in New Jersey. Bull. 815, 63 pp.

(7) New Jersey. 1954. p. 1. 1954, Realty improvement and sewerage facilities act, ch. 199 (standards for the construction of sewerage facilities for realty improvements). pp. 746–753.

(8) Rogers, Franklin C. 1950. Engineering soil survey of New Jersey. Report Number 1. Eng. Research Bull. 15, Col. of Eng., Rutgers U., 110 pp., illus.

(9) Salisbury, Rollin D. 1902. The glacial geology of New Jersey. New Jersey Geol. Survey, Final Report of the State Geologist, vol. V, 802 pp., illus.

(10) United States Department of Agriculture. 1951. Soil survey manual. U.S. Dept. Agr. Handbook 18, 503 pp., illus. [Supplement issued on May 1962.]

(11) ———— 1960. Soil classification, a comprehensive system, 7th approximation. 265 pp., illus. [Supplements issued in March 1967 and September 1968.]

(12) Waterways Experiment Station, Corps of Engineers. 1953. The unified soil classification system. Tech. Memo. 3–357, 2 v., appendix, illus.

Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Boulder. A large, rounded, detached or transported rock.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Coarse fragments. Mineral or rock particles more than 2 millimeters in diameter.

Cobble. A rounded or partly rounded fragment of rock, 3 to 10 inches in diameter.

Diversion, or diversion terrace. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils that have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Fragipan. A loamy, brittle, subsurface horizon that is very low in organic-matter content and clay but is rich in silt or very fine sand. The layer is seemingly cemented. When dry, it is hard or very hard and has a high bulk density in comparison with the horizon or horizons above it. When moist, the fragipan tends to rupture suddenly if pressure is applied, rather than to deform slowly. The layer is generally mottled, is slowly or very slowly permeable to water, and has few or many bleached fracture planes that form polygons. Fragipans are a few inches to several feet thick; they generally occur below the B horizon, 5 to 40 inches below the surface.

Glacial deposit or glacial drift (geology). Rock material transported by glacial ice and then deposited; also includes the sorted and unsorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Cross-bedded gravel, sand, and silt deposited by melt-water as it flowed from glacial ice.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gravel. Rounded or angular rock fragments that are not prominently flattened and are as much as to 3 inches in diameter.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or block structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Leaching. The removal of soluble material from soils or other material by percolating water.

Loam. Soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical mineral, and biological properties of the various horizons, and their thickness and arrangement in the soil profile.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: abundance—*few, common,*, and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *slow, moderately slow, moderate, moderately rapid,* and *rapid.*

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Stone. Rock fragment more than 10 inches in diameter if rounded or more than 15 inches along the longer axis if flattened.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface layer. A term used in nontechnical soil descriptions for one or more layers above the subsoil; generally, the A horizon.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sand loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Variant, soil. A soil having properties sufficiently different from those of other known soils to suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water for a month or more. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Water table, perched. The upper surface of a body of free ground water that is separated from an underlying body of ground water by unsaturated material.

Weathering. All physical and chemical changes produced in rocks at or near the earth's surface by atmospheric agents. These changes result in more or less complete disintegration and decomposition of the rock.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. The suitability of the soils for crops and pasture is defined in the description of each mapping unit. The capability classification system is described on pages 62 to 65. For general information about the use of soils as woodland and as wildlife habitat, refer to the sections "Woodland" and "Wildlife." Other information is given in tables as follows:

Acreage and extent, table 1, page 11.
Estimated average yields, table 3, page 65.
Engineering uses of the soils, tables 4, 5, and 6, pages 68 through 87.
Town and country planning, table 7, page 90.

Map symbol	Mapping units	Described on page	Capability unit Symbol
Ad	Adrian muck	12	VIIw-41
Ae	Alluvial land	13	VIw-86
Am	Alluvial land, wet	13	VIw-46
AnB	Annandale gravelly loam, 3 to 8 percent slopes	14	IIe-53
AnC	Annandale gravelly loam, 8 to 15 percent slopes	15	IIIe-53
BaA	Bartley loam, 0 to 3 percent slopes	16	IIw-71
BaB	Bartley loam, 3 to 8 percent slopes	16	IIe-71
BbC	Bartley gravelly loam, 8 to 15 percent slopes	17	IIIe-71
Bd	Biddeford silt loam	17	VIw-46
BoB	Boonton gravelly loam, 3 to 8 percent slopes	18	IIe-5
BoC	Boonton gravelly loam, 8 to 15 percent slopes	18	IIIe-5
BpC	Boonton and Haledon extremely stony soils, 8 to 15 percent slopes	19	VIIs-22
CaA	Califon loam, 0 to 3 percent slopes	20	IIw-71
CaB	Califon loam, 3 to 8 percent slopes	20	IIe-71
CaC	Califon loam, 8 to 15 percent slopes	20	IIIe-71
CbB	Califon gravelly loam, 3 to 8 percent slopes	20	IIe-71
CcB	Califon very stony loam, 2 to 8 percent slopes	20	VIs-75
CcC	Califon very stony loam, 8 to 15 percent slopes	21	VIs-75
CdB	Califon loam, friable subsoil variant, 3 to 8 percent slopes	22	IIe-71
Cm	Carlisle muck	22	IIIw-41
CoA	Cokesbury gravelly loam, 0 to 3 percent slopes	23	IVw-82
CoB	Cokesbury gravelly loam, 3 to 8 percent slopes	24	IVw-82
CsB	Cokesbury extremely stony loam, 0 to 8 percent slopes	24	VIIs-77
EdB	Edneyville gravelly loam, 3 to 8 percent slopes	25	IIe-58
EdC	Edneyville gravelly loam, 8 to 15 percent slopes	25	IIIe-58
EdD	Edneyville gravelly loam, 15 to 25 percent slopes	25	IVe-58
ElB	Ellington fine sandy loam, loamy subsoil variant, 3 to 8 percent slopes	26	IIw-25
ElC	Ellington fine sandy loam, loamy subsoil variant, 8 to 15 percent slopes	26	IIIe-25
ElD	Ellington fine sandy loam, loamy subsoil variant, 15 to 25 percent slopes	26	IVe-58
HaB	Haledon silt loam, 3 to 8 percent slopes	27	IIe-71
HaC	Haledon silt loam, 8 to 15 percent slopes	27	IIIe-71
HbC	Hibernia stony loam, 3 to 15 percent slopes	28	IVs-34
HlD	Hibernia very stony loam, 15 to 25 percent slopes	29	VIs-34
HoC	Holyoke rocky silt loam, 5 to 15 percent slopes	30	VIs-17
HrE	Holyoke-Rock outcrop complex, 15 to 35 percent slopes	30	VIIs-22
KlE	Klinesville shaly silt loam, 25 to 35 percent slopes	30	VIIe-66
Ma	Made land, sanitary land fill	31	-------
MlA	Minoa silt loam, 0 to 3 percent slopes	32	IIIw-70
MlB	Minoa silt loam, 3 to 8 percent slopes	32	IIIw-70
Ms	Muck, shallow over clay	32	VIIw-41
Mu	Muck, shallow over loam	32	VIIw-41
NeB	Neshaminy gravelly silt loam, 3 to 8 percent slopes	33	IIe-55
NeC	Neshaminy gravelly silt loam, 8 to 15 percent slopes	33	IIIe-55
NfD	Neshaminy very stony silt loam, 15 to 25 percent slopes	34	VIs-61
NtB	Netcong gravelly sandy loam, 3 to 8 percent slopes	35	IIe-7
NtC	Netcong gravelly sandy loam, 8 to 15 percent slopes	35	IIIe-7
OtC	Otisville gravelly loamy sand, 3 to 15 percent slopes	35	VIIs-12
OtD	Otisville gravelly loamy sand, 15 to 25 percent slopes	36	VIIs-12
PaC	Parker gravelly sandy loam, 3 to 15 percent slopes	36	IIIe-58

Map symbol	Mapping unit	Described on page	Capability unit
			Symbol
PbD	Parker very gravelly sandy loam, 15 to 25 percent slopes	36	VIs-58
PeC	Parker-Edneyville extremely stony sandy loams, 3 to 15 percent slopes	37	VIIs-22
PeD	Parker-Edneyville extremely stony sandy loams, 15 to 25 percent slopes	37	VIIs-22
PfE	Parker-Rock outcrop complex, 20 to 35 percent slopes	37	VIIs-22
Ph	Parsippany silt loam	39	IVw-80
Pk	Parsippany silt loam, sandy loam substratum	39	IVw-81
PlB	Pattenburg gravelly loam, 3 to 8 percent slopes	40	IIe-58
PlC	Pattenburg gravelly loam, 8 to 15 percent slopes	40	IIIe-58
PnB	Penn shaly silt loam, 3 to 8 percent slopes	41	IIe-65
PnC	Penn shaly silt loam, 8 to 15 percent slopes	41	IIIe-65
PoD	Penn-Klinesville shaly silt loams, 15 to 25 percent slopes	41	VIe-65
Ps	Pits, sand and gravel	41	-------
PtA	Pompton sandy loam, 0 to 3 percent slopes	42	IIw-25
PtB	Pompton sandy loam, 3 to 8 percent slopes	42	IIw-25
PvA	Preakness sandy loam, 0 to 4 percent slopes	43	IVw-36
Pw	Preakness sandy loam, dark surface variant	44	IVw-36
ReB	Reaville shaly silt loam, deep variant, 0 to 5 percent slopes	45	IIw-70
RgA	Ridgebury very stony loam, 0 to 3 percent slopes	46	VIIs-38
RlB	Ridgebury extremely stony loam, 3 to 10 percent slopes	46	VIIs-38
RmA	Riverhead gravelly sandy loam, 0 to 3 percent slopes	47	I-7
RmB	Riverhead gravelly sandy loam, 3 to 8 percent slopes	47	IIe-7
RmC	Riverhead gravelly sandy loam, 8 to 15 percent slopes	47	IIIe-7
RnB	Riverhead gravelly sandy loam, neutral variant, 2 to 8 percent slopes	48	IIe-7
RoB	Rockaway gravelly sandy loam, 3 to 8 percent slopes	50	IIe-5
RoC	Rockaway gravelly sandy loam, 8 to 15 percent slopes	50	IIIe-5
RpC	Rockaway very stony sandy loam, 3 to 15 percent slopes	50	VIs-19
RrD	Rockaway extremely stony sandy loam, 15 to 25 percent slopes	50	VIIs-22
RsC	Rockaway-Rock outcrop complex, 3 to 15 percent slopes	51	VIIs-22
RsD	Rockaway-Rock outcrop complex, 15 to 25 percent slopes	51	VIIs-22
RsE	Rockaway-Rock outcrop complex, 25 to 45 percent slopes	51	VIIIs-23
Rt	Rock outcrop	52	VIIIs-23
RvF	Rock outcrop-Rockaway complex, steep	52	VIIIs-23
TuA	Turbotville loam, 0 to 3 percent slopes	53	IIw-71
TuB	Turbotville loam, 3 to 8 percent slopes	53	IIe-71
Ua	Urban land	53	-------
Ub	Urban land, wet	53	-------
Ue	Urban land-Edneyville complex	53	-------
Uh	Urban land-Haledon complex	54	-------
Uk	Urban land-Neshaminy complex	54	-------
Um	Urban land-Penn complex	54	-------
Un	Urban land-Preakness complex	54	-------
Up	Urban land-Riverhead complex	54	-------
UrC	Urban land-Rockaway complex, gently sloping and sloping	54	-------
UrD	Urban land-Rockaway complex, moderately steep	55	-------
Uw	Urban land-Whippany complex	55	-------
WaB	Washington loam, 0 to 8 percent slopes	56	IIe-54
WhA	Whippany silt loam, 0 to 3 percent slopes	57	IIIw-70
WhB	Whippany silt loam, 3 to 8 percent slopes	57	IIIw-70
WlA	Whippany silt loam, sandy loam substratum, 0 to 3 percent slopes	57	IIIw-70
WlB	Whippany silt loam, sandy loam substratum, 3 to 8 percent slopes	57	IIIw-70
Wm	Whitman very stony loam	58	VIIs-45

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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

NEW JERSEY AGRICULTURAL EXPERIMENT STATION
COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCE

GENERAL SOIL MAP

MORRIS COUNTY, NEW JERSEY

Scale 1:190,080

1 0 1 2 3 4 Miles

N

SUSSEX COUNTY
WARREN COUNTY
HUNTERDON COUNTY
SOMERSET COUNTY
PASSAIC COUNTY
ESSEX COUNTY
UNION COUNTY
MORRIS COUNTY

JEFFERSON
WASHINGTON
ROCKAWAY
RANDOLPH
MENDHAM
CHESTER
ROXBURY
MOUNT OLIVE
MINE HILL
DENVILLE
BOONTON
MONTVILLE
PEQUANNOCK
PARSIPPANY-TROY HILLS
HANOVER
EAST HANOVER
MORRISTOWN
HARDING
CHATHAM
PASSAIC

Woodport
Woodstock
Marcella
Kinnelon
Butler
Riverdale
Pompton Plains
Pequannock
Lincoln Park
Taylortown
Hibernia
Mt Arlington
Lake Hopatcong
Oak Ridge Reservoir
Charlotteburg Reservoir
Splitrock Reservoir
Boonton Reservoir
Green Pond
Picatinny Lake
Musconetcong Lake
Budd Lake
Netcong
Ledgewood
Rockaway
Wharton
Dover
Denville
Victory Gardens
Mountain Lakes
Lake Hiawatha
Pine Brook
Troy Hills
Morris Plains
Whippany
Hanover
Florham Park
Madison
Chatham
New Vernon
Millington
Meyersville
Succasunna
Schooleys Mountain
Long Valley
Middle Valley
Naughright
Ironia
Mount Freedom
Brookside
Mendham
Chester

41°00′
40°50′
40°40′
74°50′
74°40′
74°30′
74°20′

SOIL ASSOCIATIONS *

SOILS FORMED IN YOUNG GLACIAL TILL

1 Rockaway-Hibernia-Urban land association: Deep, well drained to somewhat poorly drained, gently sloping to steep gravelly sandy loams and stony to extremely stony loams and sandy loams that overlie granitic gneiss; on uplands

2 Rockaway-Rock outcrop association: Deep, well drained and moderately well drained, strongly sloping to very steep very stony and extremely stony sandy loams that overlie granitic gneiss, and strongly sloping to very steep rock outcrops; on uplands

3 Netcong-Rockaway association: Deep, well drained and moderately well drained, gently sloping to very steep gravelly, very stony, and extremely stony sandy loams that overlie granitic gneiss; on uplands

4 Holyoke-Haledon-Boonton association: Shallow and deep, well drained to somewhat poorly drained, gently sloping to very steep rocky silt loams, silt loams, gravelly loams, and extremely stony loams that overlie basalt or shale; on uplands

5 Haledon-Urban land-Boonton association: Deep, well drained to somewhat poorly drained, gently sloping and strongly sloping silt loams, gravelly loams, and extremely stony loams that overlie basalt or shale; on uplands

SOILS FORMED IN ORGANIC DEPOSITS, GLACIAL LAKE SEDIMENT, OR GLACIAL OUTWASH

6 Riverhead-Urban land-Pompton association: Deep, well drained to somewhat poorly drained, nearly level to strongly sloping gravelly sandy loams and sandy loams that overlie stratified outwash sand and gravel; on outwash plains and terraces

7 Carlisle-Parsippany-Preakness association: Deep, poorly drained and very poorly drained, nearly level mucks, silt loams, and sandy loams that overlie stratified lacustrine sand, silt, and clay or stratified outwash sand and gravel; in depressions or along low-gradient streams

8 Parsippany-Biddeford-Whippany association: Deep, somewhat poorly drained to very poorly poorly drained, nearly level and gently sloping silt loams that overlie stratified lacustrine sand, silt, and clay; on broad lowlands

SOILS FORMED IN OLD GLACIAL DEPOSITS OR IN MATERIAL WEATHERED FROM BEDROCK

9 Neshaminy-Ellington, loamy subsoil variant, association: Deep, well drained to somewhat poorly drained, gently sloping to steep fine sandy loams, gravelly silt loams, and very stony silt loams that overlie basalt or shale; on uplands

10 Penn-Reaville, deep variant-Urban land association: Deep and moderately deep, well drained to somewhat poorly drained, nearly level to steep shaly silt loams that overlie shale; on uplands

11 Califon-Annandale-Cokesbury association: Deep, well drained to poorly drained, nearly level to strongly sloping loams, gravelly loams, very stony loams, and extremely stony loams that overlie granitic gneiss; on uplands

12 Edneyville-Parker-Califon association: Deep, excessively drained to somewhat poorly drained, gently sloping to steep gravelly loams, very gravelly sandy loams, very stony loams, and extremely stony sandy loams that overlie granitic gneiss; on uplands

13 Parker-Edneyville association: Deep, excessively drained and well drained, steep to very steep very gravelly sandy loams, gravelly loams, and extremely stony sandy loams that overlie granitic gneiss; on uplands

14 Bartley-Turbotville-Cokesbury association: Deep, moderately well drained to poorly drained, nearly level to strongly sloping loams and gravelly loams that overlie limestone or granitic gneiss; on terraces

*Texture terms refer to the surface layer of the major soils in each association.

Compiled 1974

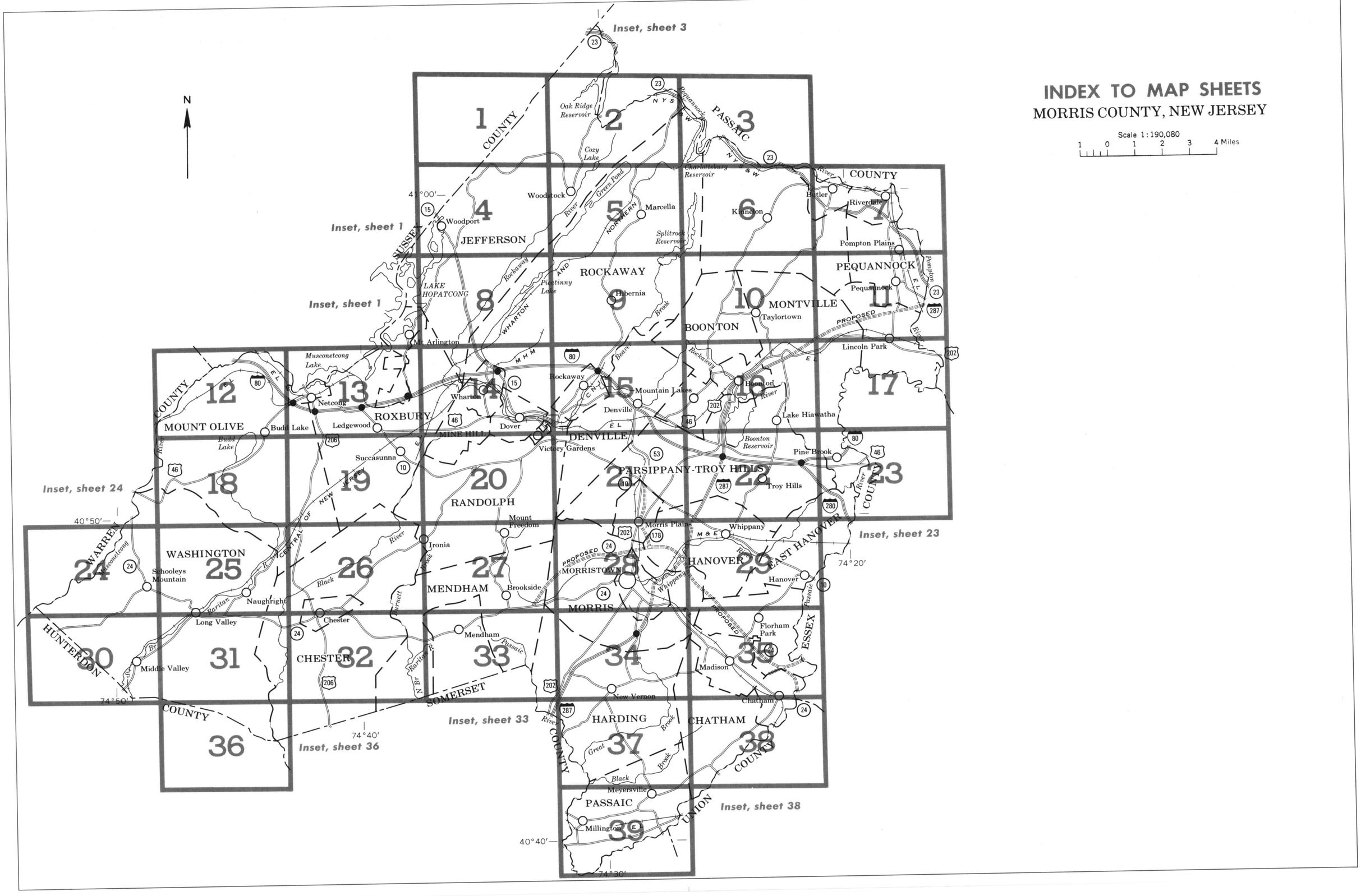
Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

INDEX TO MAP SHEETS

MORRIS COUNTY, NEW JERSEY

Scale 1:190,080

1 0 1 2 3 4 Miles



SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, or F, shows the slope. Most symbols without a slope letter are those of nearly level soils, but some are for land types or soil complexes that have a considerable range of slope.

SYMBOL	NAME
Ad	Adrian muck
Ae	Alluvial land
Am	Alluvial land, wet
AnB	Annandale gravelly loam, 3 to 8 percent slopes
AnC	Annandale gravelly loam, 8 to 15 percent slopes
BaA	Bartley loam, 0 to 3 percent slopes
BaB	Bartley loam, 3 to 8 percent slopes
BbC	Bartley gravelly loam, 8 to 15 percent slopes
Bd	Biddeford silt loam
BoB	Boonton gravelly loam, 3 to 8 percent slopes
BoC	Boonton gravelly loam, 8 to 15 percent slopes
BpC	Boonton and Haledon extremely stony soils, 8 to 15 percent slopes
CaA	Califon loam, 0 to 3 percent slopes
CaB	Califon loam, 3 to 8 percent slopes
CaC	Califon loam, 8 to 15 percent slopes
CbB	Califon gravelly loam, 3 to 8 percent slopes
CcB	Califon very stony loam, 2 to 8 percent slopes
CcC	Califon very stony loam, 8 to 15 percent slopes
CdB	Califon loam, friable subsoil variant, 3 to 8 percent slopes
Cm	Carlisle muck
CoA	Cokesbury gravelly loam, 0 to 3 percent slopes
CoB	Cokesbury gravelly loam, 3 to 8 percent slopes
CsB	Cokesbury extremely stony loam, 0 to 8 percent slopes
EdB	Edneyville gravelly loam, 3 to 8 percent slopes
EdC	Edneyville gravelly loam, 8 to 15 percent slopes
EdD	Edneyville gravelly loam, 15 to 25 percent slopes
ElB	Ellington fine sandy loam, loamy subsoil variant, 3 to 8 percent slopes
ElC	Ellington fine sandy loam, loamy subsoil variant, 8 to 15 percent slopes
ElD	Ellington fine sandy loam, loamy subsoil variant, 15 to 25 percent slopes
HaB	Haledon silt loam, 3 to 8 percent slopes
HaC	Haledon silt loam, 8 to 15 percent slopes
HbC	Hibernia stony loam, 3 to 15 percent slopes
HlD	Hibernia very stony loam, 15 to 25 percent slopes
HoC	Holyoke rocky silt loam, 5 to 15 percent slopes
HrE	Holyoke-Rock outcrop complex, 15 to 35 percent slopes
KlE	Klinesville shaly silt loam, 25 to 35 percent slopes
Ma	Made land, sanitary land fill
MlA	Minoa silt loam, 0 to 3 percent slopes
MlB	Minoa silt loam, 3 to 8 percent slopes
Ms	Muck, shallow over clay
Mu	Muck, shallow over loam
NeB	Neshaminy gravelly silt loam, 3 to 8 percent slopes
NeC	Neshaminy gravelly silt loam, 8 to 15 percent slopes
NfD	Neshaminy very stony silt loam, 15 to 25 percent slopes
NtB	Netcong gravelly sandy loam, 3 to 8 percent slopes
NtC	Netcong gravelly sandy loam, 8 to 15 percent slopes
OtC	Otisville gravelly loamy sand, 3 to 15 percent slopes
OtD	Otisville gravelly loamy sand, 15 to 25 percent slopes
PaC	Parker gravelly sandy loam, 3 to 15 percent slopes
PbD	Parker very gravelly sandy loam, 15 to 25 percent slopes
PeC	Parker-Edneyville extremely stony sandy loams, 3 to 15 percent slopes
PeD	Parker-Edneyville extremely stony sandy loams, 15 to 25 percent slopes
PfE	Parker-Rock outcrop complex, 20 to 35 percent slopes
Ph	Parsippany silt loam
Pk	Parsippany silt loam, sandy loam substratum
PlB	Pattenburg gravelly loam, 3 to 8 percent slopes
PlC	Pattenburg gravelly loam, 8 to 15 percent slopes
PnB	Penn shaly silt loam, 3 to 8 percent slopes
PnC	Penn shaly silt loam, 8 to 15 percent slopes
PoD	Penn-Klinesville shaly silt loams, 15 to 25 percent slopes
Ps	Pits, sand and gravel
PtA	Pompton sandy loam, 0 to 3 percent slopes
PtB	Pompton sandy loam, 3 to 8 percent slopes
PvA	Preakness sandy loam, 0 to 4 percent slopes
Pw	Preakness sandy loam, dark surface variant
ReB	Reaville shaly silt loam, deep variant, 0 to 5 percent slopes
RgA	Ridgebury very stony loam, 0 to 3 percent slopes
RlB	Ridgebury extremely stony loam, 3 to 10 percent slopes
RmA	Riverhead gravelly sandy loam, 0 to 3 percent slopes
RmB	Riverhead gravelly sandy loam, 3 to 8 percent slopes
RmC	Riverhead gravelly sandy loam, 8 to 15 percent slopes
RnB	Riverhead gravelly sandy loam, neutral variant, 2 to 8 percent slopes
RoB	Rockaway gravelly sandy loam, 3 to 8 percent slopes
RoC	Rockaway gravelly sandy loam, 8 to 15 percent slopes
RpC	Rockaway very stony sandy loam, 3 to 15 percent slopes
RrD	Rockaway extremely stony sandy loam, 15 to 25 percent slopes
RsC	Rockaway-Rock outcrop complex, 3 to 15 percent slopes
RsD	Rockaway-Rock outcrop complex, 15 to 25 percent slopes
RsE	Rockaway-Rock outcrop complex, 25 to 45 percent slopes
Rt	Rock outcrop
RvF	Rock outcrop-Rockaway complex, steep
TuA	Turbotville loam, 0 to 3 percent slopes
TuB	Turbotville loam, 3 to 8 percent slopes
Ua	Urban land
Ub	Urban land, wet
Ue	Urban land-Edneyville complex
Uh	Urban land-Haledon complex
Uk	Urban land-Neshaminy complex
Um	Urban land-Penn complex
Un	Urban land-Preakness complex
Up	Urban land-Riverhead complex
UrC	Urban land-Rockaway complex, gently sloping and sloping
UrD	Urban land-Rockaway complex, moderately steep
Uw	Urban land-Whippany complex
WaB	Washington loam, 0 to 8 percent slopes
WhA	Whippany silt loam, 0 to 3 percent slopes
WhB	Whippany silt loam, 3 to 8 percent slopes
WlA	Whippany silt loam, sandy loam substratum, 0 to 3 percent slopes
WlB	Whippany silt loam, sandy loam substratum, 3 to 8 percent slopes
Wm	Whitman very stony loam

MORRIS COUNTY, NEW JERSEY

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads

- Divided
- Good motor
- Poor motor
- Trail

Highway markers

- National Interstate
- U. S.
- State or county

Railroads

- Single track
- Multiple track
- Abandoned

Bridges and crossings

- Road
- Trail
- Railroad
- Ferry — FY
- Ford — FORD
- Grade
- R. R. over
- R. R. under

Buildings

School

Church

Mine and quarry — QU.

Gravel pit — G.P.

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout station

Mine shaft

Located object

BOUNDARIES

- National or state
- County
- Minor civil division
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line

- Perennial
- Intermittent

Streams, single-line

- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Unclassified

Canals and ditches

Lakes and ponds

- Perennial — water, w
- Intermittent — int

Spring

Marsh or swamp

Wet spot

Drainage end or alluvial fan

RELIEF

Escarpments

- Bedrock
- Other

Short steep slope

Prominent peak

Depressions

	Large	Small
Crossable with tillage implements		
Not crossable with tillage implements		
Contains water most of the time		

SOIL SURVEY DATA

Soil boundary and symbol — Dx

Gravel

Stoniness
- Stony
- Very stony

Rock outcrops

Chert fragments

Clay spot

Sand spot

Gumbo or scabby spot

Made land

Severely eroded spot

Blowout, wind erosion

Gully

(1)

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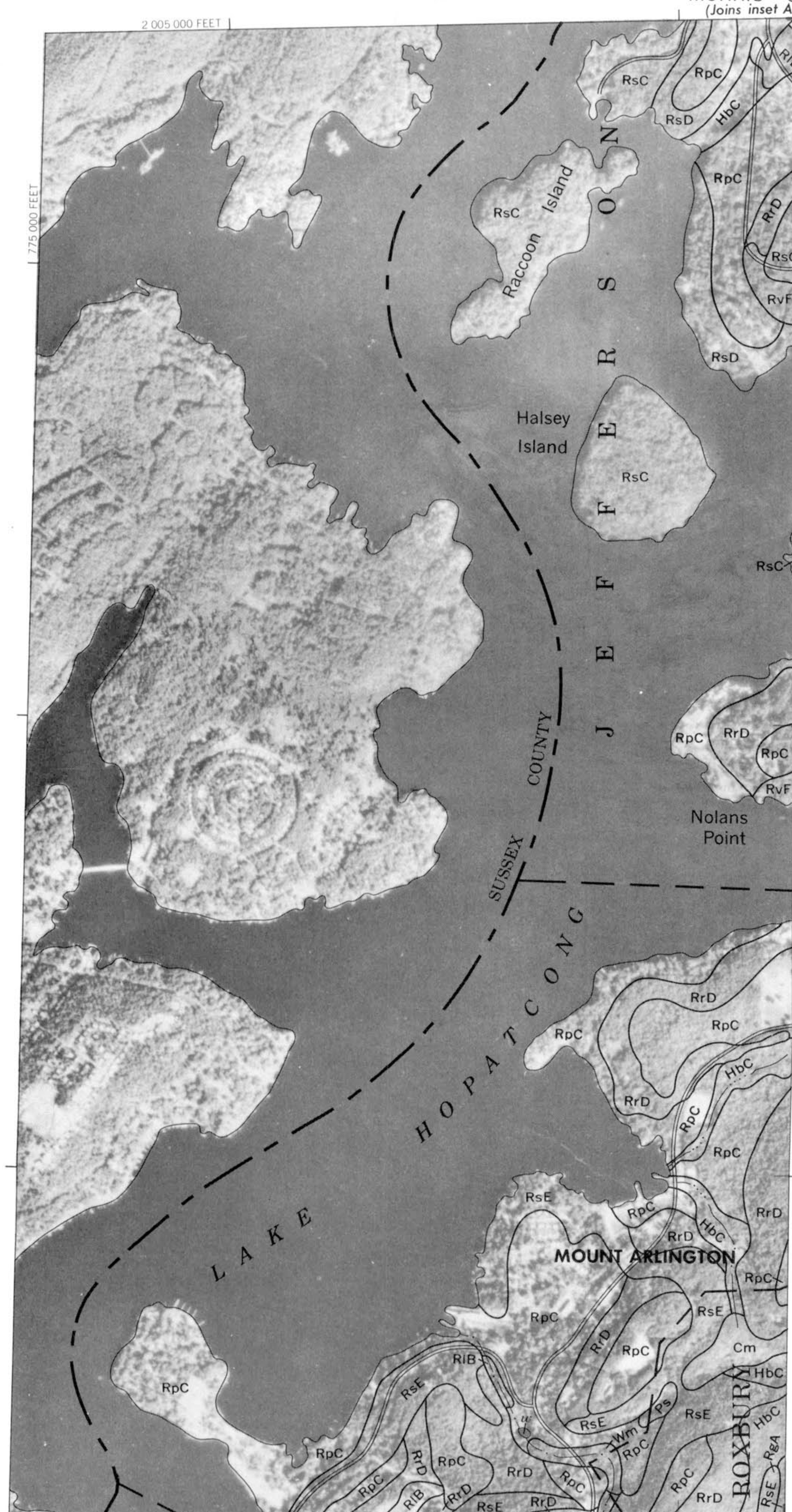
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.
MORRIS COUNTY, NEW JERSEY NO. 1

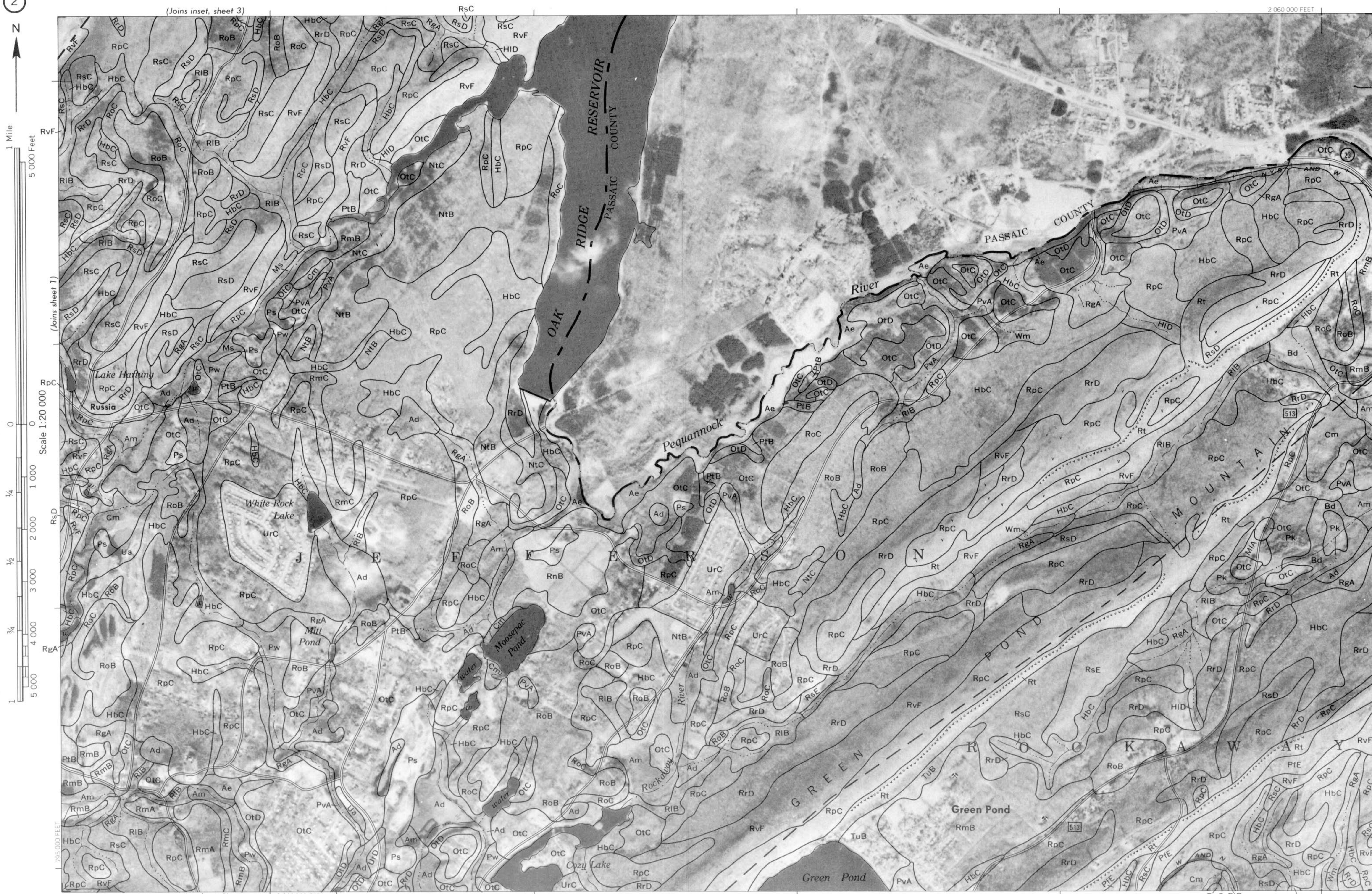
INSET B



N

1 Mile
5 000 Feet
Scale 1:20 000

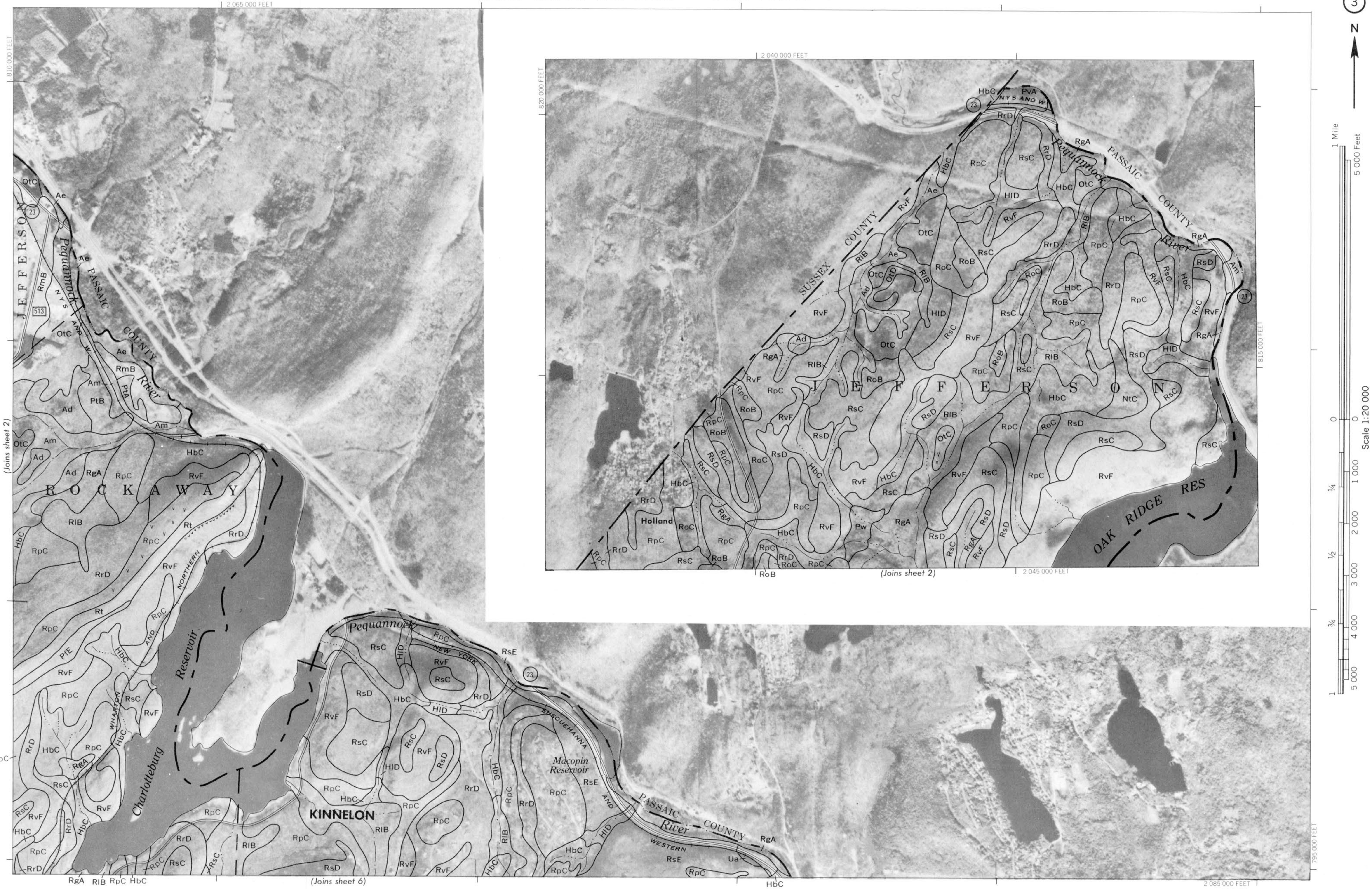
MORRIS COUNTY, NEW JERSEY — SHEET NUMBER 2



MORRIS COUNTY, NEW JERSEY NO. 2

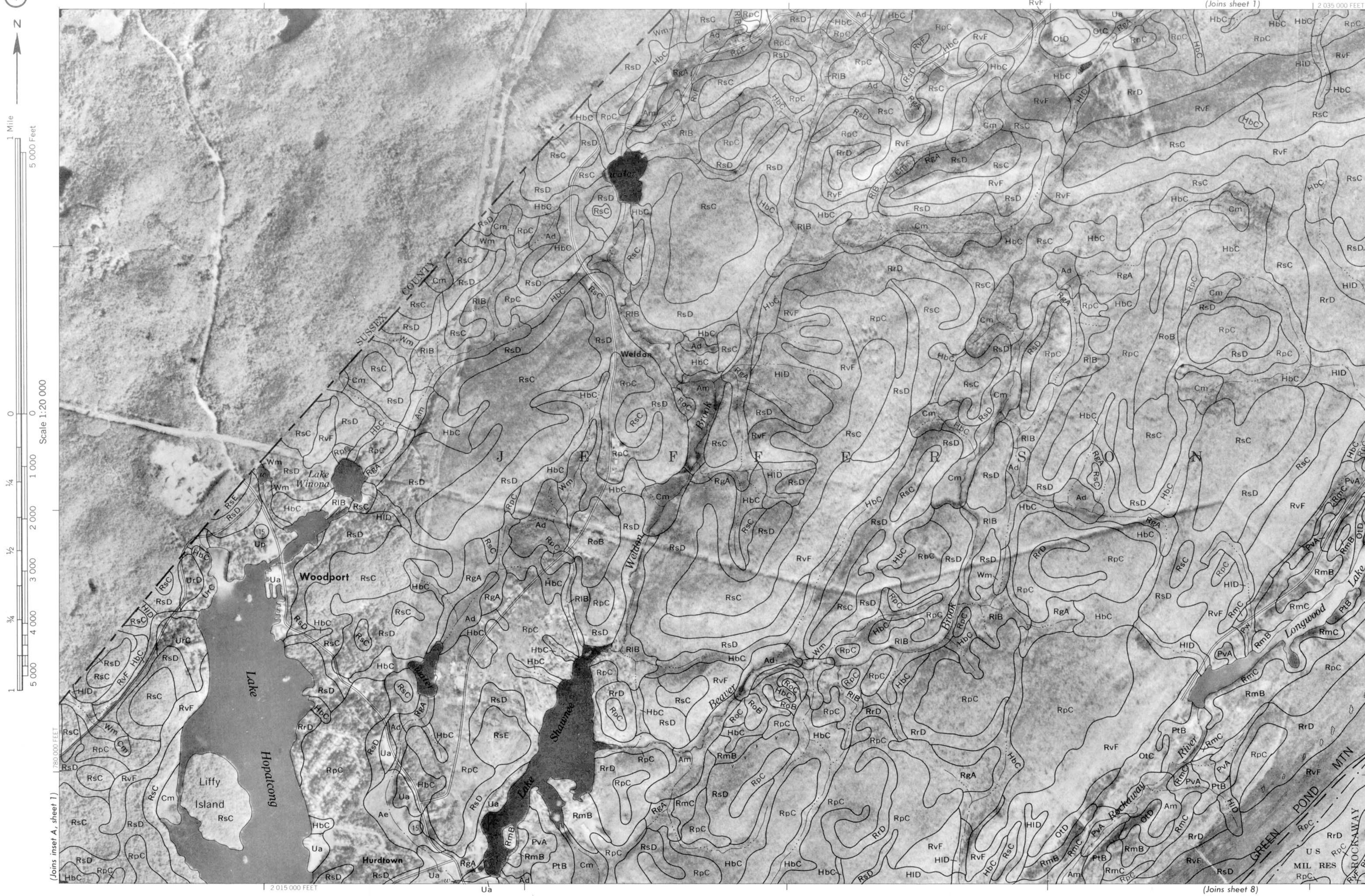
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Service.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Science. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 3

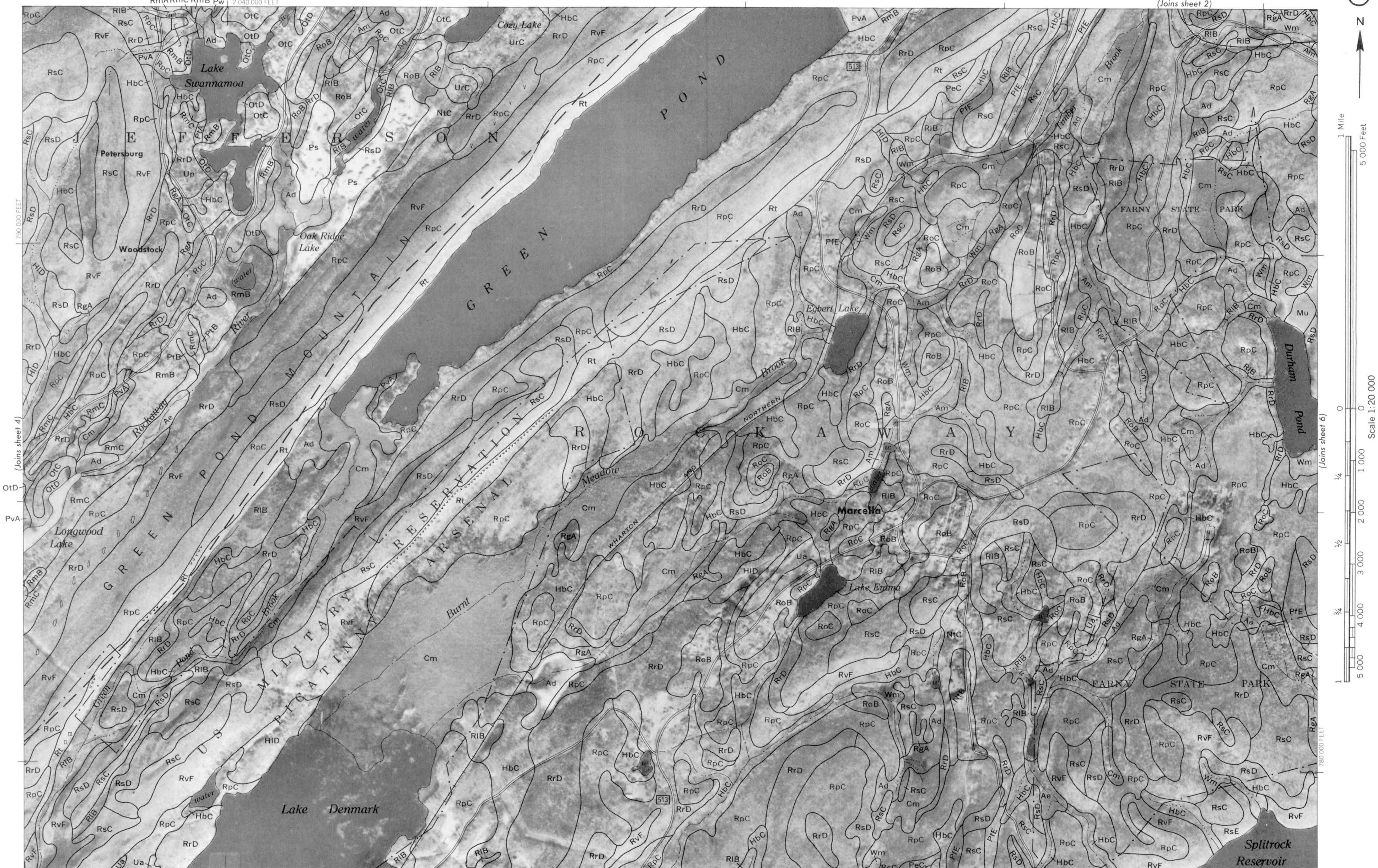


MORRIS COUNTY, NEW JERSEY NO. 4

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Science.

5



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Science.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system
MORRIS COUNTY, NEW JERSEY NO. 5

N

Scale 1:20 000

1 Mile 5 000 Feet

0 0

¼ 1 000

½ 2 000

¾ 3 000

1 4 000

5 000

(Joins sheet 3)

(Joins sheet 5)

(Joins sheet 7)

(Joins sheet 10)

2 085 000 FEET

790 000 FEET

780 000 FEET

2 065 000 FEET

Pequannock River

PASSAIC COUNTY

NY S AND W

BUTLER

Terrace Lake

Maple Lake

Smoke Rise

Hoot Owl Lake

Durham Pond

Lake Kinnelon

New Pond

KINNELON

Splitrock Reservoir

Butler Reservoir

Fayson Lakes

West Fayson Lake

East Lake

South Fayson Lake

Lake Rickabean

PARK

STATE

FARM

water

MORRIS COUNTY, NEW JERSEY NO. 6

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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MORRIS COUNTY, NEW JERSEY NO. 7
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Service.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

7
N

1 Mile
5 000 Feet
Scale 1:20 000
0
1/4
1/2
3/4
1
1 000
2 000
3 000
4 000
5 000

N

1 Mile
5 000 Feet
Scale 1:20 000
0
1 000
2 000
3 000
4 000
5 000

(Joins sheet 4)
(Joins inset B, sheet 1)
(Joins sheet 14)
(Joins sheet 9)

2 035 000 FEET
775 000 FEET
765 000 FEET
2 015 000 FEET

LAKE HOPATCONG
Hurdtown
Tierneys Corner
Espanong
MOUNT ARLINGTON
ROXBURY
JEFFERSON
US MILITARY RESERVATION
PICATINNY ARSENAL
ROCKAWAY
Rockaway
Picatinny Lake
Mt Hope
Mt Hope Pond
Mt Hope Lake
Green Pond
NORTHERN AND WHARTON BOUNDARY
MT HOPE MINERAL RES

MORRIS COUNTY, NEW JERSEY NO. 8
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.
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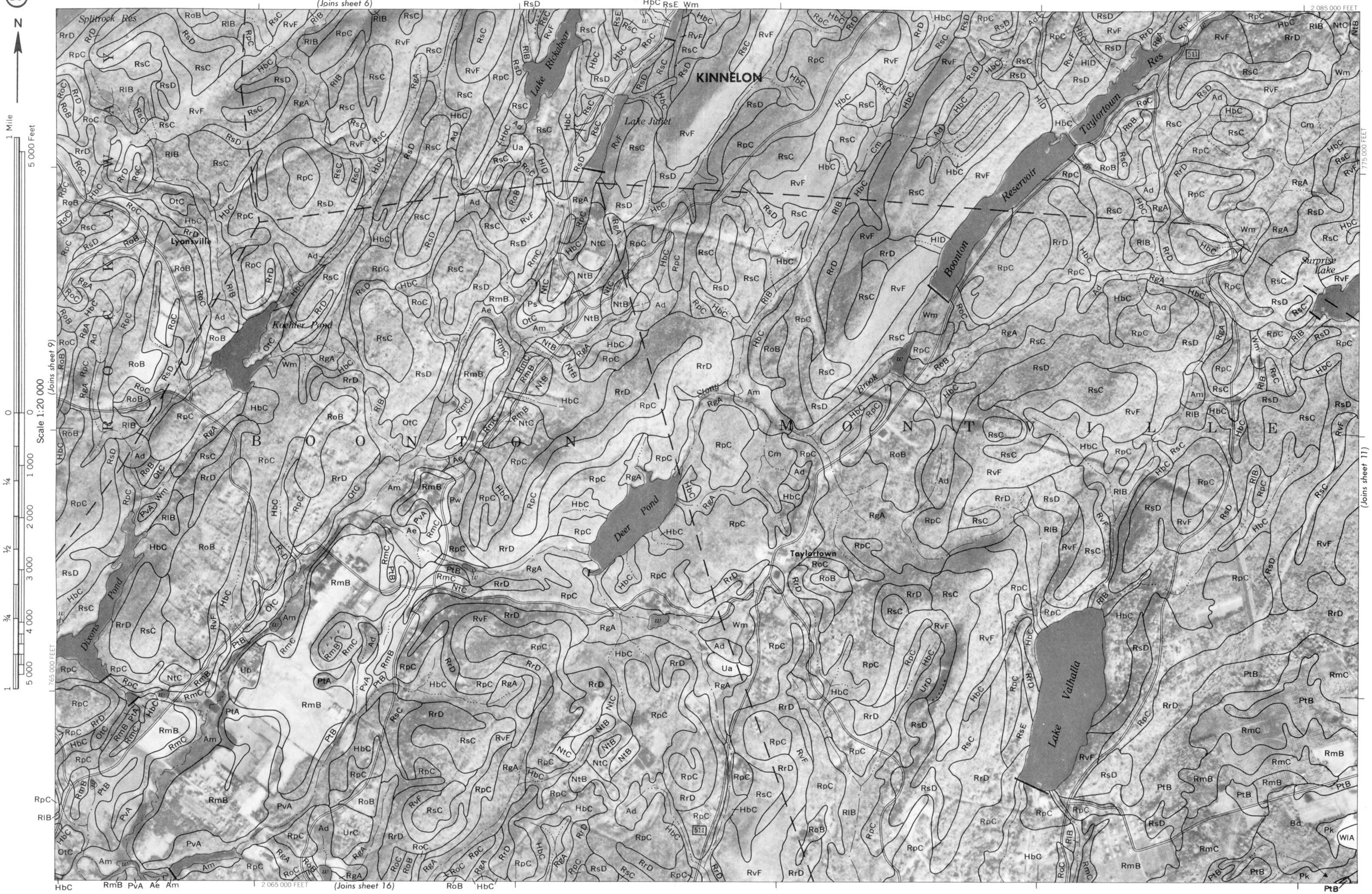
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY — SHEET NUMBER 10



MORRIS COUNTY, NEW JERSEY NO. 10

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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MORRIS COUNTY, NEW JERSEY NO. 11

(Joins sheet 7)
(Joins sheet 10)
(Joins sheet 17)

2 090 000 FEET
775 000 FEET
765 000 FEET
2 110 000 FEET

KINNELON
POMPTON PLAINS
PEQUANNOCK
LINCOLN PARK
MONTVILLE
TOWACO
Jacksonville
Surprise Lake
Untermeyer Lake
Township Pond
RIVER
PASSAIC COUNTY
POMPTON
LACKAWANNA
ERIE
INTERSTATE HWY 287
PROPOSED
water

11
N

1 Mile
5 000 Feet
Scale 1:20 000

MORRIS COUNTY, NEW JERSEY NO. 12

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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13

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Science.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.
MORRIS COUNTY, NEW JERSEY NO. 13

N

1 Mile
5 000 Feet
Scale 1:20 000
0 ¼ ½ ¾ 1
0 1000 2000 3000 4000 5000

MORRIS COUNTY, NEW JERSEY — SHEET NUMBER 14

N

1 Mile

Scale 1:20 000

0 ¼ ½ ¾ 1

0 1 000 2 000 3 000 4 000 5 000 Feet

MORRIS COUNTY, NEW JERSEY NO. 14

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 15

15

N

Scale 1:20 000

1 Mile

5 000 Feet

(Joins sheet 14)
(Joins sheet 9)
(Joins sheet 16)
(Joins sheet 21)

2 040 000 FEET
760 000 FEET
2 060 000 FEET
745 000 FEET

(Joins sheet 10)

2 085 000 FEET

760 000 FEET

N

1 Mile

5 000 Feet

0 0

Scale 1:20 000

1/4 1 000

1/2 2 000

3/4 3 000

1 4 000

5 000

(Joins sheet 15)

(Joins sheet 17)

(Joins sheet 22)

245 000 FEET

2 065 000 FEET

ROCKAWAY

BOONTON

DENVILLE

MONTVILLE

MOUNTAIN LAKES

PARSIPPANY-TROY HILLS

LAKE HIAWATHA

Powerville

Griffith Pond

Hood Pond

Wildwood Lake

Mountain Lake

Lake Intervale

Lake Montowae

Lower Montville

Lake Hiawatha

RESERVOIR

RIVER

ERIE

LACKAWANNA

Rockaway River

INTERSTATE HWY. 287

PROPOSED

511

202

287

46

MORRIS COUNTY, NEW JERSEY NO. 16

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 17

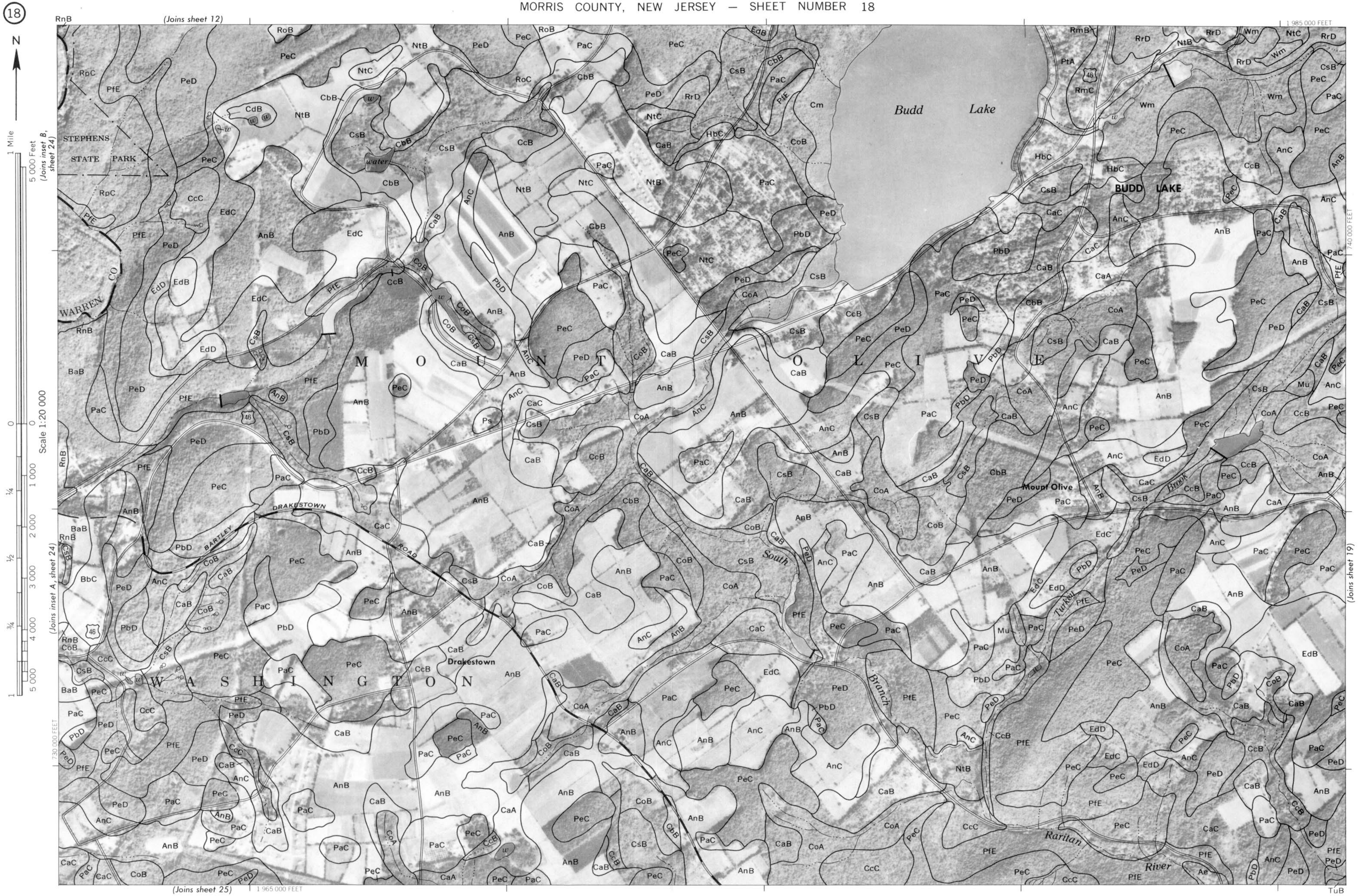
(Joins sheet 11)
(Joins sheet 16)
(Joins sheet 23)

2 090 000 FEET
760 000 FEET
745 000 FEET
2 110 000 FEET

TOWACO
LINCOLN PARK
MONTVILLE
POMPTON
RIVER
PASSAIC
ESSEX
COUNTY
ROAD
BROOK
PINE
ERIE
LACKAWANNA

17
N

1 Mile
5 000 Feet
Scale 1:20 000



MORRIS COUNTY, NEW JERSEY NO. 18

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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MORRIS COUNTY, NEW JERSEY NO. 19

19

N

1 Mile
5 000 Feet

Scale 1:20 000

(Joins sheet 14)

2 035 000 FEET

N

1 Mile

5 000 Feet

Scale 1:20 000

(Joins sheet 19)

0 0

1 000

¼

2 000

½

3 000

¾

4 000

1

5 000

730 000 FEET

740 000 FEET

(Joins sheet 21)

(Joins sheet 27)

2 015 000 FEET

ROXBURY

MINE HILL

RANDOLPH

DOVER

VICTORY GARDENS

Black River

Jackson Brook

Dalrymple Pond

Lake Cherokee

Shongum Lake

Black River Pond

Sons of Poland Camp

water

MORRIS COUNTY, NEW JERSEY NO. 20

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.
MORRIS COUNTY, NEW JERSEY NO. 21

(Joins sheet 20)
(Joins sheet 15)
(Joins sheet 22)
(Joins sheet 28)

2 040 000 FEET
740 000 FEET
730 000 FEET
2 060 000 FEET

Franklin
Union Hill
Mount Tabor
Mount Tabor Lake
Power Mill Pond
Openaka Lake
GREYSTONE PARK STATE HOSPITAL
MORRIS PLAINS
PARSIPPANY-TROY HILLS
HANOVER
MORRIS
PROPOSED

21
N

1 Mile
5 000 Feet
Scale 1:20 000
0 0
¼ 1 000
½ 2 000
¾ 3 000
1 4 000
5 000

N

Scale 1:20 000

1 Mile

5 000 Feet

1 000

2 000

3 000

4 000

5 000

1/4

1/2

3/4

1

2 085 000 FEET

730 000 FEET

2 065 000 FEET

740 000 FEET

(Joins sheet 16)

(Joins sheet 21)

(Joins sheet 23)

(Joins sheet 29)

MOUNTAIN LAKES

PARSIPPANY

MONTVILLE

PARSIPPANY-TROY HILLS

HANOVER

EAST HANOVER

BOONTON RESERVOIR

Lake Parsippany

Forge Pond

Brick Yard Pond

TROY HILLS

water

Troy

Brook

Rockaway

River

West

Eastmans

DITCH

SMITH

Whippany

MORRIS COUNTY, NEW JERSEY NO. 22

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 23

MORRIS COUNTY, NEW JERSEY NO. 24

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 25

25

N

1 Mile
5 000 Feet
0
Scale 1:20 000
¼ 1 000
½ 2 000
¾ 3 000
1 4 000
5 000

(Joins sheet 19)

2 010 000 FEET

N

1 Mile
5 000 Feet

Scale 1:20 000

1 000 2 000 3 000 4 000 5 000 FEET

(Joins sheet 25)

715 000 FEET

1 990 000 FEET

(Joins sheet 32)

725 000 FEET

(Joins sheet 27)

MORRIS COUNTY, NEW JERSEY NO. 26

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 27

(Joins sheet 26)

(Joins sheet 20)

(Joins sheet 28)

(Joins sheet 33)

2 015 000 FEET

725 000 FEET

715 000 FEET

2 035 000 FEET

27

N

1 Mile

5 000 Feet

Scale 1:20 000

0 1 000 2 000 3 000 4 000 5 000

¼ ½ ¾ 1

Ironia

Coleman's Hollow

Mount Freedom

Clyde Potts Reservoir

Brookside

MENDHAM

RANDOLPH

MORRIS

SUSSEX TURNPIKE

MT PLEASANT ROAD

MOUNTAINSIDE ROAD

Whippany River

Harmony Brook

India Brook

Sunrise Lake

HARDING HWY

PROPOSED STATE

N

Scale 1:20 000

1 Mile 5 000 Feet 1 000 Meters

(Joins sheet 21)

(Joins sheet 27)

(Joins sheet 29)

(Joins sheet 34)

2 060 000 FEET

725 000 FEET

715 000 FEET

2 040 000 FEET

MORRIS PLAINS

PARSIPPANY TROY HILLS

GREYSTONE PARK STATE HOSPITAL

HANOVER

CEDAR KNOLLS

MORRISTOWN (county seat)

Jaqui Pond

Speedwell Lake

Lake Pocahontas

Whippany River

PROPOSED HWY 24

STATE HWY 24

HANOVER AVENUE

MORRISTOWN BLVD.

QUEEN ST.

ERIE

DELAWARE, LACKAWANNA & WESTERN

MORRIS COUNTY, NEW JERSEY NO. 28

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Service.

MORRIS COUNTY, NEW JERSEY — SHEET NUMBER 29

29

N

2 065 000 FEET

725 000 FEET

715 000 FEET

2 085 000 FEET

(Joins sheet 22)

(Joins inset, sheet 23)

(Joins sheet 28)

(Joins sheet 35)

PARSIPPANY-TROY HILLS

WHIPPANY

Malapardis

Monroe

Birch Hills

MORRISTOWN AIRPORT

FLORHAM PARK

EAST HANOVER

Hanover

MORRIS

HANOVER

Whippany River

Black Brook

Troy Brook

Smith Ditch

Passaic River

Passaic County

Essex County

Morristown and Erie

Interstate — Hwy 287

Under Const

Proposed

Hwy 24

1 Mile

5 000 Feet

Scale 1:20 000

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 29

N

1 Mile 5 000 Feet

Scale 1:20 000

0 0

¼ 1 000

½ 2 000

¾ 3 000

1 4 000 5 000

(Joins sheet 24)

1 960 000 FEET

710 000 FEET

Pleasant Grove

Scroppy Corner

Middle Valley

Crestmoore

HUNTERDON COUNTY

MORRIS COUNTY

PLEASANT GROVE ROAD

MIDDLE VALLEY ROAD

CENTRAL AVE.

SCHOOLEYS MTN.

NEW JERSEY RIVER OF RARITAN

WASHINGTON

TOWN

WEST BRANCH

SOUTH BRANCH

513

(Joins sheet 31)

695 000 FEET

1 940 000 FEET

MORRIS COUNTY, NEW JERSEY NO. 30

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 31

31

N

Scale 1:20 000

1 Mile
5 000 Feet
1 000 0 0 1 000 2 000
¼ ½ ¾ 1
5 000 4 000 3 000

1 965 000 FEET
710 000 FEET
1 985 000 FEET
695 000 FEET

(Joins sheet 25)
(Joins sheet 30)
(Joins sheet 32)
(Joins sheet 36)

WASHINGTON
CHESTER
FOX HILL
RANGE
Milltown
Hacklebarney
HACKLEBARNEY STATE PARK
Parker
Black River
South Branch Raritan River
Tanners Brook
Trout Brook
Fourmile Brook
QUARRY
ROAD
HUNTERDON CO

MORRIS COUNTY, NEW JERSEY NO. 32

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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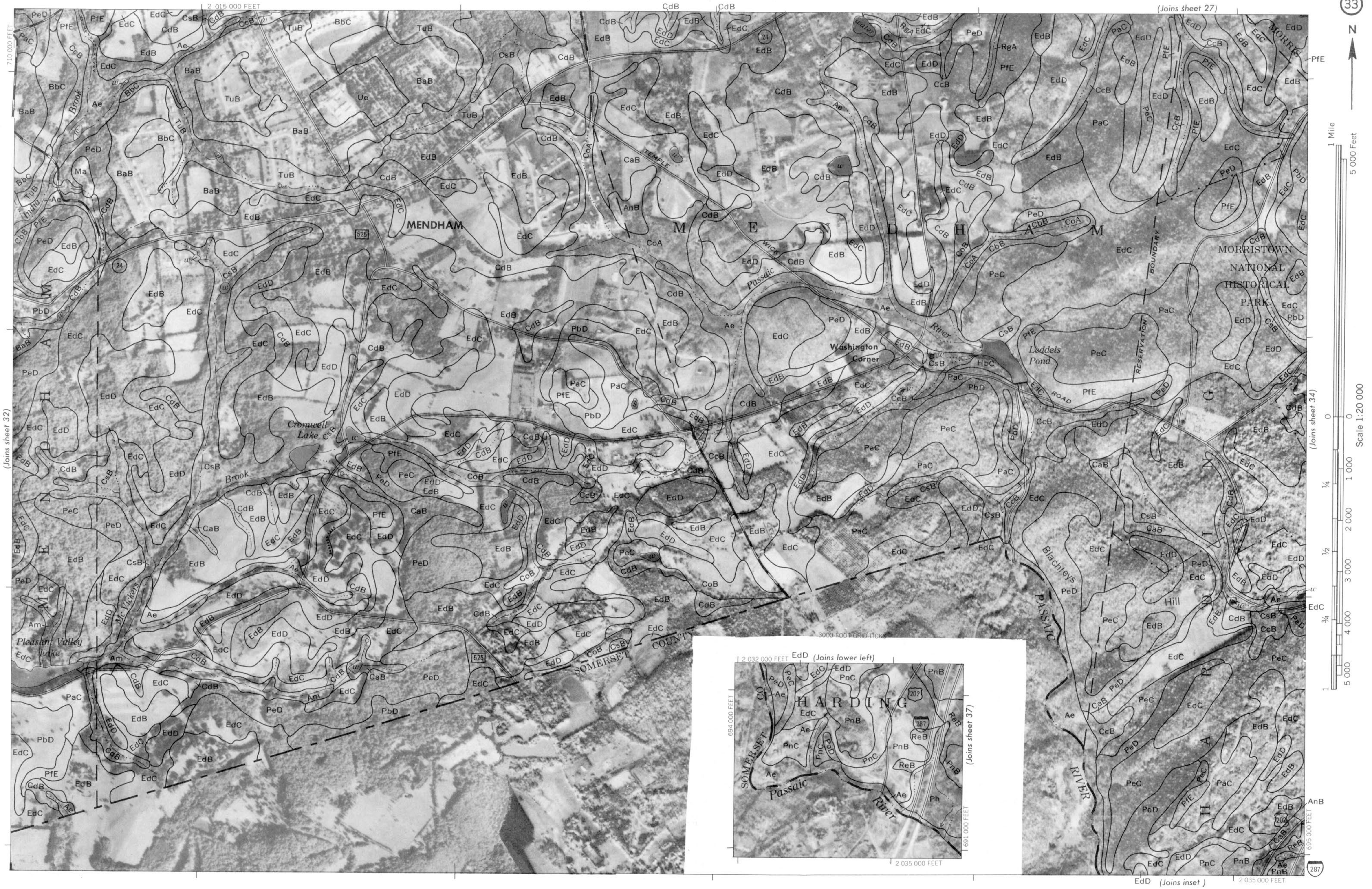
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 33



N

1 Mile

5 000 Feet

0

Scale 1:20 000

1 000 0 1 000 2 000 3 000 4 000 5 000

1/4 1/2 3/4 1

(Joins sheet 28)

(Joins sheet 33)

(Joins sheet 35)

(Joins sheet 37)

2 060 000 FEET

710 000 FEET

695 000 FEET

2 040 000 FEET

MORRISTOWN
(county seat)

MORRISTOWN NATIONAL HISTORICAL PARK

Gillespie Hill

Sugar Loaf

Mount Kemble

Tea Hill

Glen Alpin

Kemble Mtn.

Spring Lake

Golf Course

water

Mount Kemble Lake

New Vernon

Silver Lake

Great Brook

Loantaka Brook

WOODLAND AVENUE

MORRIS COUNTY, NEW JERSEY NO. 34

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

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This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Service.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

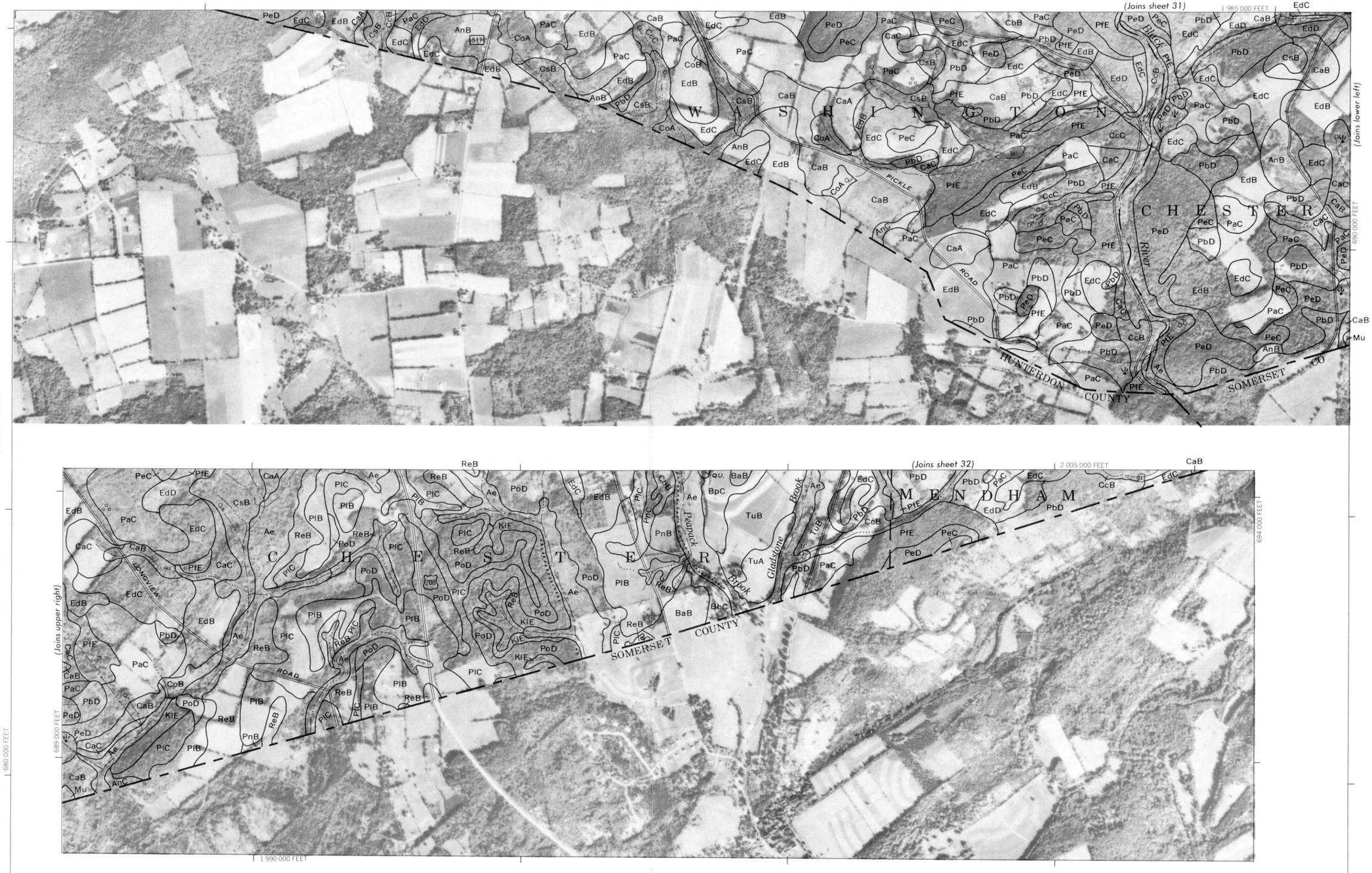
MORRIS COUNTY, NEW JERSEY NO. 35

(Joins sheet 29)
(Joins sheet 34)
(Joins sheet 38)

2 065 000 FEET
710 000 FEET
695 000 FEET
2 085 000 FEET

35
N

1 Mile
5 000 Feet
Scale 1:20 000
0 1 000 2 000 3 000 4 000 5 000
0 ¼ ½ ¾ 1



MORRIS COUNTY, NEW JERSEY NO. 36

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Service.

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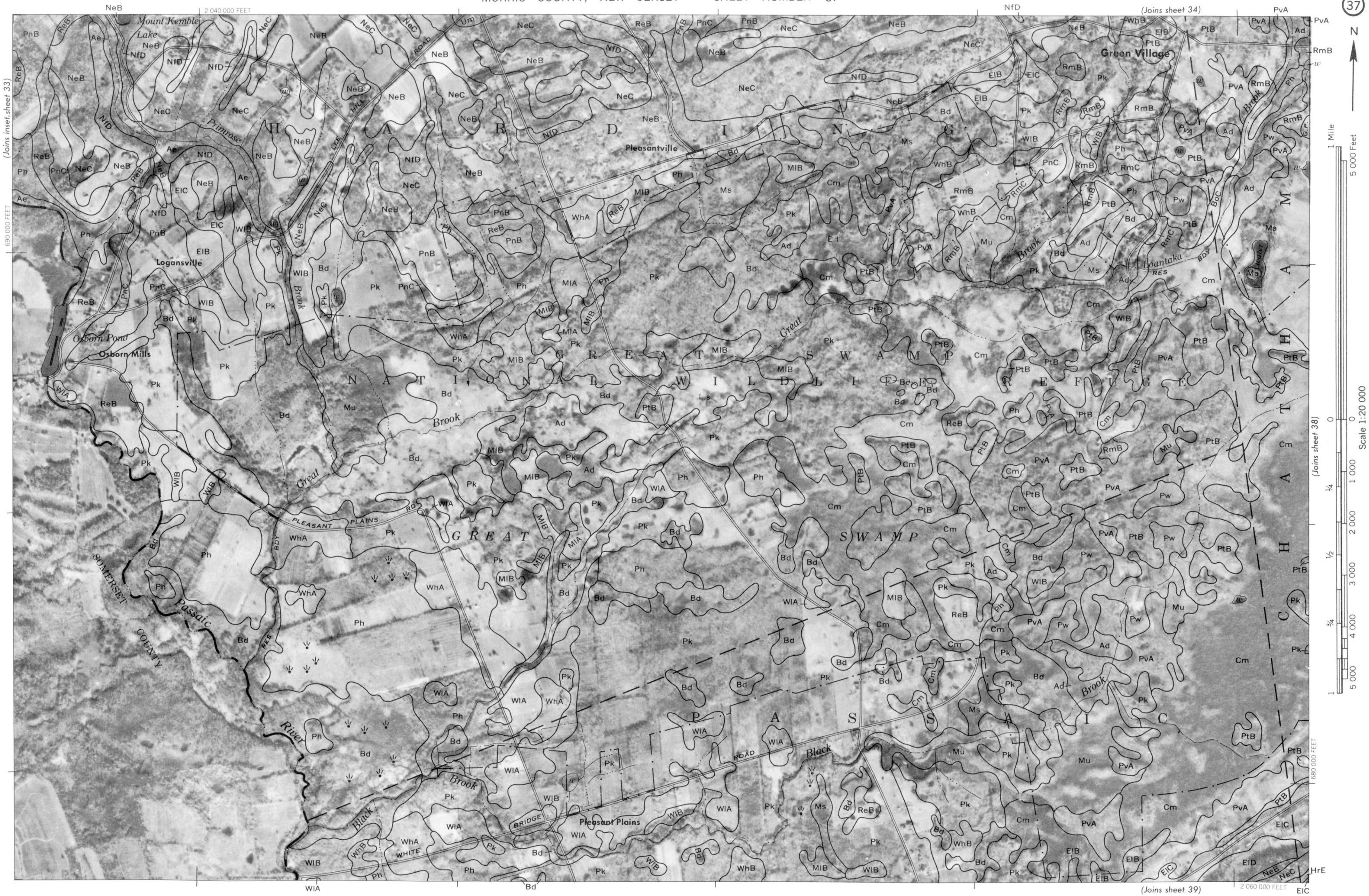
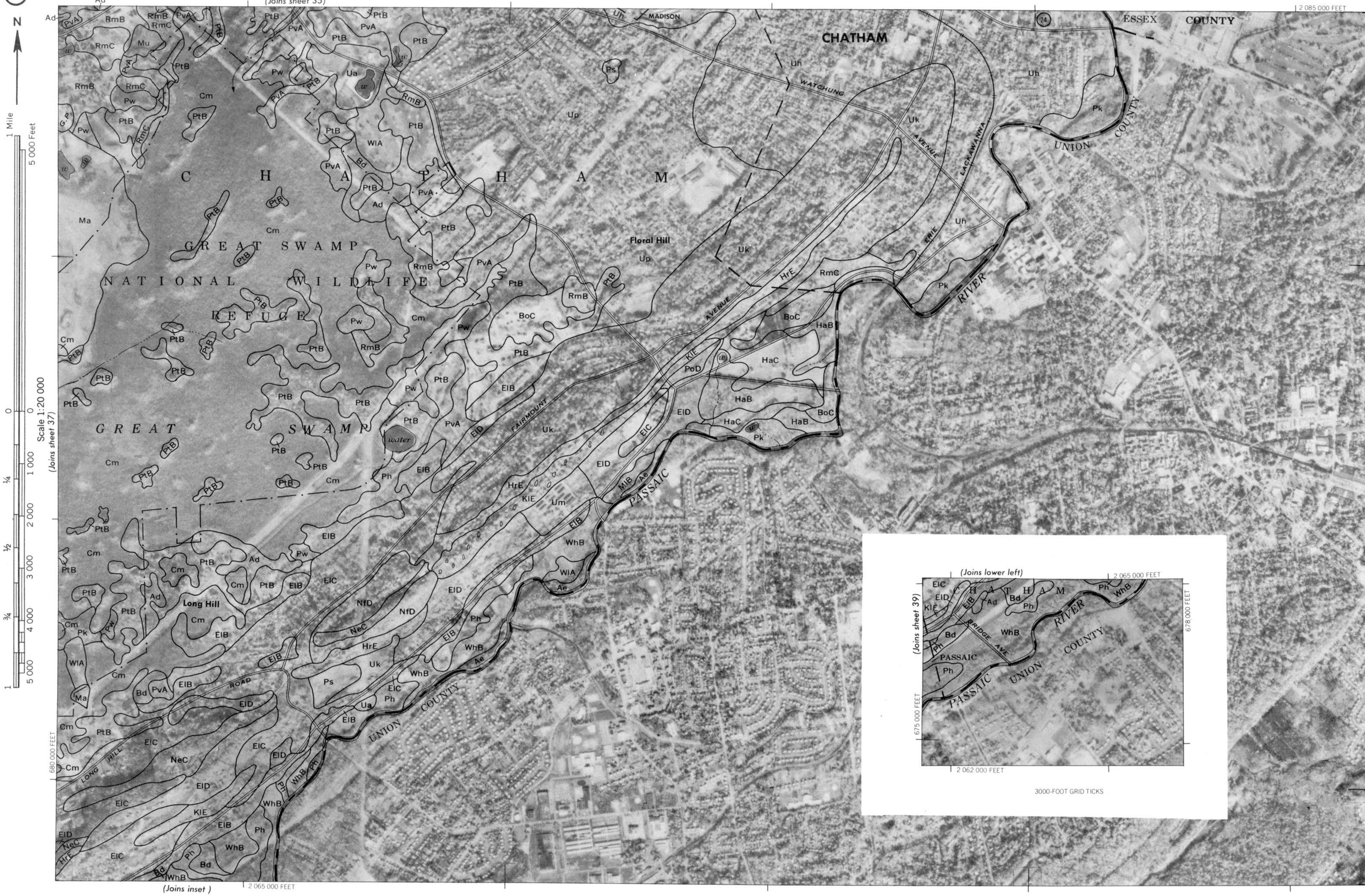
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.
MORRIS COUNTY, NEW JERSEY NO. 37





MORRIS COUNTY, NEW JERSEY NO. 38

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, the New Jersey Agricultural Experiment Station, and the College of Agriculture and Environmental Service.

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the New Jersey coordinate system.

MORRIS COUNTY, NEW JERSEY NO. 39

2 040 000 FEET

675 000 FEET

(Joins sheet 37)

(Joins inset, sheet 38)

665 000 FEET

2 060 000 FEET

39

N

1 Mile

5 000 Feet

Scale 1:20 000

0 0

¼ 1 000

½ 2 000

¾ 3 000

1 4 000

5 000